Our Own and Other Worlds

Joseph Hamilton

OUR OWN AND OTHER WORLDS

BY

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INTRODUCTION BY

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With Illustrations

"Such a world as Saturn seems a very Paradise, where the redeemed of
the Lord might walk, where angels might soar and sing." *Page 75.*

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Introduction.

THIS book is exceedingly well written and instructive. Dr. Hamilton has thoroughly mastered and digested the literature on astronomy, and interprets its technical information into the language of common life. He gives the results of the latest thought and discovery on the subject. He makes the conceptions of the vast spaces of the universe more real by using the journey of a railway train, and the transfer of sound and light, as measurements. The argument in favor of other worlds being inhabited is exceedingly strong and cumulative, and has won the commendation of eminent astronomers. The book would be eminently suitable for day school, Sunday school, and popular libraries, and would be highly educative in its character, as well as fascinating in its interest.

REV. W. H. WITHROW, D.D., F.R.S.C.

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Our Own and Other Worlds

CHAPTER I.

A WONDERFUL STORY.

Instinct of curiosity—A story of surpassing interest—Narrative of facts—The realm of the wonderful—Instruments used in astronomy—Glory of creation—Other worlds—Happy escape from materialism—A most inspiring study—Domain of the mental and spiritual.

I AM going to tell a true story. The fact that the story is really true ought surely to make it the more interesting. We all love a story so well that often we read it when we know it is not true, and we are loth to lay the book down until we see how everything ends in the last chapter. Such is the strong instinct of curiosity implanted in every human breast. And this is a good instinct, only it needs to be well directed ; and I think it is well directed in this story, because the story is not only true, but of surpassing interest.

Yet this is not a story of flood and fire, of storm and shipwreck, of surprises and escapes, of love and hate, of jealousy and revenge, of " battle and murder and sudden death." No. This is a story of the stars. A story of the stars, you say! Surely that cannot be a very lively or interesting tale. You have seen the stars shining in the sky every night since you were a child, and you cannot see how they can furnish much material for a story. Well, just read on for a little, and I think you will find this story of the stars to be as interesting as a novel.

I say this because I have noticed that many people who are otherwise well educated and intelligent are very hazy in their thoughts about the starry sky. Astronomy is scarcely or not at all taught in the schools, and those who give it any special attention in their later years are very few; hence the too general want of information on this most fascinating theme. More than this, the books that have been published on the stars

USUALLY GO TOO FAR

into the science of astronomy for ordinary readers, until what ought to be fascinating becomes only obscure. Thus many readers are discouraged from taking up a book on astronomy, feeling that even if the subject can be made interesting, it must be so only to those who have gone deeply into the science.

Now you need have no fears of that kind in regard to this treatise of mine. The most wonderful things about the stars

CAN BE KNOWN JUST AS WELL

by those who are not astronomers as by those who are. These wonderful things make up the tale that I wish to unfold. I shall deal mainly with the things that are certain—not with the things that are uncertain or obscure. There are a great many things towards which astronomers are only feeling their way, and about which they can hardly help speculating. Such obscure and uncertain things I shall for the most part leave alone; or if I do touch on some of them, I shall present them

ONLY AS MEN'S OPINIONS OR GUESSES,

not to be received as facts until they are proved. In the science of the stars there is a wide realm of the wonderful in ascertained facts, and these will form the main substance of my story.

I shall not worry you, either, by trying to tell you how men found out these wonderful things about the stars, except, perhaps, in a few cases where there was something striking in the way the discoveries were made. It will be enough to give the facts themselves.

The chief instruments which atronomers use in making discoveries are the telescope, the spectroscope, and the photograph. The telescope enlarges distant objects to our view, so that they can be more critically examined; and it brings objects into view that are too small or too remote to be seen otherwise. The spectroscope deals chiefly with the nature of light, and enables us to judge of the substances in the bodies from which the light proceeds. The photograph makes pictures of objects by light, and is now used in connection with the telescope in giving us

PICTURES OF STARS

so far away that the telescope of itself could not bring them into view.

With these instruments there must be combined a great knowledge of mathematics, to make certain calculations. There must also be a wide acquaintance with the ascertained laws of nature. Especially must an astronomer know the motions of the heavenly bodies, so far as these are ascertained. Along with all this, there needs to be an accurate knowledge of such stars as have been observed. It is also essential to know what others have done in the past in the way of discovery. With the instruments I have named, together with these branches of knowledge, astronomers have, from time to time, found out the wonderful things I shall refer to in this story of the stars.

You will see, then, that you do not need to be yourself an astronomer in order to enjoy the

WONDER AND GLORY

of creation. We can see with our mind what the astronomer sees with the telescope. And this gives us a wider and quicker view, with far less labor. We need not, then, envy the man who looks through the telescope. I think we are really better placed than he is for appreciating the wonders of this wonderful universe. We can combine what the astronomers have done in the past; and thus getting the benefit of their united labors, we enter into the heritage of the genius of the world.

Compared with us, then, the poor astronomer is but a drudge, working hard at his telescope night by night, to be rewarded, it may be, by some new discovery, or, more likely, not to be so rewarded at all. These rewards are only for the few. But we do not need to drudge at all. We simply take the results of those who have labored for us; and this rich legacy puts us in possession of the glory of a boundless universe.

I think we shall not have gone far with our story till you feel inclined to ask whether

OTHER WORLDS THAN OUR OWN

are inhabited. Indeed, you may be disposed to ask that question at the outset. A mere glance at the starry sky is enough to suggest the question: Are there any living beings in those stars? Well, we shall give that question some attention later on. We shall be in a better position to discuss it when we look at the sizes, the conditions, the appointments of other worlds; and see how those worlds compare with our own. We may, then, perhaps, be able to form an intelligent idea as to whether there is life, and intelligence, and enjoyment in any of those upper spheres.

Now, there may be some who will say that any study of the starry heavens is far too theoretic for this age. In this practical age, you say, we need to prosecute subjects that will pay. The stars are not going to rain gold. Astronomy will put no money in our purse. We want the earth, or as much of it as we can acquire; the dreamers are welcome to the stars.

Now, in my view, it is just because this age is so very practical that our tale of the stars is so very much in place. A tale of this kind provides a wholesome escape from the grinding materialism of our time. Beset as we are, morning, noon, and night, by questions as to what we shall eat and wear, and how much wealth we can accumulate, and what vulgar show we can make in the world, is it not a blessed relief to

RISE INTO SOME HIGH DOMAIN

where houses, and land, and trade, and vulgar show count for nothing? The stars make a man wholesomely little; at the same time, they remind him that he is an immortal, with an immortal destiny. Surely it is well to have such an escape now and then from the dull, hard, oppressive materialism of our time.

Then I claim for astronomy that it is one of the most uplifting and inspiring studies that can engage the human mind. Here we are lifted from the realm of the narrow and contracted into the realm of the vast and sublime. From the pettifogging calculations of a day's loss or gain in land or lard, we are launched into the blazing immensities of the starry hosts. We are not trifling when we leave the ultra-practical behind and below. There are other gains than those that go into the pocket. We can afford to lose something in the domain of the material, if thereby we are enriched in the higher domains of the mental and the spiritual.

CHAPTER II.

THE EARTH HERSELF A STAR.

The dwellers on Venus—Sun's light reflected—Radiant cottage windows—Glowing clouds in the west—Size of the earth—Her form—Her thin crust—Ocean of fire below—Volcanic eruptions—Earth's motion on axis—Movement round the sun—Amazing accuracy as to time—The earth's poise in her orbit—Variety of seasons—Superstition of scepticism—The undevout astronomer.

THIS earth of ours is a star. She is not a star, of course, to us who live upon her; but if there are dwellers on other globes, she is a star to them—that is, if they are not too far away. To those who may live on Venus, for instance, the earth would be a star, as Venus is now to us; and she would appear about as large as Venus. If others live on the moon the earth would be a star to them, but she would appear fifteen times larger than the moon appears to us. This difference in the apparent size of the earth, as seen from Venus or from the moon, is owing to the difference in distance. It is a universal law that the farther distant any object is, the smaller it appears; and this law has always to be reckoned with in observing the heavenly bodies. It is the same law that makes a man appear

LIKE A LARGE INSECT

when repairing a church spire, or that makes a large ship seem only like a dot on the far horizon of the sea.

But how comes it that the earth is a star to other worlds since the earth itself is a dark body? It is because it reflects the light of the sun. So the earth can be a bright star to worlds far away, while it is dark to us who dwell upon it. We are not in the right place to get any benefit from its light. You have often seen the windows of some humble cottage flashing with glory in the rays of the setting sun. But when you came close to the cottage the radiance disappeared; and perhaps the windows were dirty, or patched, or broken. So it is that the sun can make this dim old world of ours radiant to the dwellers in other spheres.

Or, look at those dark, heavy clouds in the western sky. By and by when the sun is setting, those dark masses of vapor become radiant; the heavy, murky clouds are changed into burning crimson thrones. It is thus that the sun illuminates the earth and all the planets that surround him. Even Venus,

BY FAR THE BRIGHTEST OF THEM ALL,

has no light whatever of her own. That she has such exceeding brilliancy is owing, probably, to her surface being peculiarly adapted for reflecting the sun's light.

In point of size the earth and Venus are more nearly alike than any others of the heavenly bodies that we know. And is the earth really no larger than that beautiful evening star? No; the two are almost of the same bulk. And, although Venus is our nearest neighbor, except our own moon, there is an immense distance between us; and it is this distance which makes each appear but as a star to the other.

Still, the earth is an immense globe, so long as we do not compare it with others that are larger. If a train could make a complete circuit of it, speeding on at the rate of

A THOUSAND MILES A DAY,

twenty-five days and nights would be required to make the trip. Perhaps that is about as good a way as any of realizing the size of this earth home of ours.

Then, as we have just hinted, the earth is a round body. It is not perfectly round, however; being flattened a little at the poles, and bulging a little at the equator. This is a matter of small moment in itself, but it helps to sustain a certain theory called the nebular theory, about which we may have something to say later on. Practically, the earth is round. I believe there are yet a few people who think it is flat, like a southern negro preacher who made the flatness of the earth a very essential point of doctrine. One proof of the

ROUNDNESS OF THE EARTH

that is often cited is the fact that if you watch a vessel sailing out on a calm sea, her hull is the first part of her that disappears, and she gradually seems to sink until her masts are lost to sight. This shows that there is a bulge on the ocean, and in consequence a roundness of the whole globe. The earth itself is too large, and we are too close to it, to see the roundness of it at one view; just as a very small insect alighting on an orange cannot see far enough to realize that the orange is round. Or, if you travel round the world in what seems to you a straight line, say from east to west, you come back to the point whence you started. Then you realize that your supposed straight line was actually a circle, and that the world must be round.

But we ought to stay here a moment to note the fact that this earth is not so solid a body as it seems. We speak of the solid earth, and the everlasting hills; but there is no solid earth, and there are no everlasting hills. We are living, instead, on a thin crust or shell, which in proportion to the size of the earth is far thinner than the shell of an egg; in fact the shell of a bubble is a much nearer proportion. Like a bubble, too, the shell sometimes bursts. For, but a little way beneath our feet there is a raging,

MOLTEN SEA OF FIRE

which is ever in danger of bursting the shell and enveloping the world in flames.

We see plain evidence of this in every earthquake and volcano. Yet though the volcano is so dangerous, it acts as a safety valve in giving vent to this surging tide of fire. Still, quite often there has been a fiery deluge, burying whole cities in lava or ashes. In the year 1169 Mount Etna poured forth a torrent of lava which destroyed the city of Catania with 15,000 inhabitants. In 1779 there was an eruption of Vesuvius, with showers of stones, and a river of lava from which the flames rose two miles in height. An earlier eruption of Vesuvius buried the city of Pompeii under twenty feet of ashes, so that even the site of the city was not discovered for sixteen hundred years. And many other eruptions, more or less disastrous, have occurred in different ages of the world. To crown all, we have had just lately the fearful

ERUPTION OF MOUNT PELEE,

which overwhelmed a city of twenty thousand inhabitants, of whom it is said that but one man survived.

These awful visitations show that the thin shell of the earth has not thickened much during many centuries past. Calculations have been made to show about how thick is the shell that separates us from this tornado of fire. Every miner knows that the mine grows hotter the deeper he goes down. It is calculated that the temperature rises about one degree for each thirty yards we go beneath the surface. At this rate water would boil at two miles down ; iron would melt at seven miles ; and the hardest substances we know would melt at twenty-eight miles. Therefore, the whole interior of the earth below twenty-eight miles must be an ocean of fire. But what are twenty-eight miles compared with the whole volume of the earth ? Only the one three hundreth part of the earth's diameter. Was I not right, then, in comparing the earth to a bubble ?

I have taken this notice of the internal condition of the earth because, like the flattening of the poles referred to, it is one circumstance that is held to favor the nebular hypothesis, which we shall glance at by and by.

Now if the earth is not a solid body because of her internal fires

BREAKING THROUGH HER THIN SHELL,

there is also another sense in which she may be said not to be a solid body. I mean that she is never at rest. She seems very firm and stable; but as a matter of fact, she has two different motions which she keeps up steadily, and has kept up through the ages past. I might say, indeed, that the earth has three motions; but two of them only we shall think of now.

First, she moves on her axis. Suppose an iron rod were passed through the earth from pole to pole, and projecting a little outside of each pole, and that the earth were to spin round on these two pivots; that is the motion on her axis. She is actually spinning round in that way, only she requires no iron rod to keep her in position. And she turns round once in about twenty-four hours. It is this movement which gives us day and night. As the earth is a round body, the sun can light up only the half of her that it turned towards him; therefore, in that half of her it is day. On the half that is turned away from him it is night. Where the day and night meet there is twilight; the twilight of morning where the earth is turning towards the sun, and the twilight of the evening where she is turning away from him.

Now there are two curious and beautiful things about this movement which we must notice. One is the amazing accuracy with which these revolutions are made. They are made, not only to the minute, but to the second. So far as known, the earth has never been

A SECOND AHEAD OF TIME,

or behind it. Hence we set our watches by the sun, as we say; but it is the movement, not of the sun but of the earth, that is so accurate. I suppose there never was a watch made by man that would keep the time to a second for one year; but the earth keeps the time to a second for a thousand years. What a stupendous marvel of adjustment we have here.

When we speak of the rising and setting sun, therefore, we mean that the sun seems to rise and set. Strictly speaking, he does neither; it is the earth that turns to the sun, and turns away from him. And so, the Bible uses the same expression; for it was necessary above all things that the Bible should use language that people could understand. If it had spoken of the earth moving round the sun

MEN WOULD HAVE BEEN CONFUSED,

and could not have believed the record. Not for thousands of years did anybody know that it was the earth that moved. The negro preacher, to whom I referred above, had a great sermon on "The Sun do Move;" the simple-minded man taking the Bible words in the literal, not in the popular sense. The same devotion to the letter, instead of to the spirit of the Word, has led more educated men into worse errors.

Now the other curious and beautiful thing about this daily movement of the earth is the way in which we have longer days in the summer, and shorter in winter. This is arranged by the peculiar way in which the earth is placed in reference to the sun. The earth moves round the sun once a year. Now, consider how it would be if the axis of the earth were placed exactly horizontal to her path round the sun. In that case, one half the earth would have a long, long day; and the other half would have a long, long night. At the poles there would be day for six months, and night for six months. Spin round on her axis as she might, there would be one half of her which she could never turn into the sun's light for six months, and the other half she could never turn away from the sun during the same period.

But suppose, on the other hand, that the earth's axis were placed perpendicular to her path round the sun. In that case, there would be no variety at all in our days and nights. Rather, indeed, there would be

NEITHER DAY NOR NIGHT

at the poles, but constant twilight, the sun appearing all the time just on the horizon. A short way from the poles the sun would appear a little above the horizon. At the equator he would pass overhead every day. But everywhere the days and nights would be equal.

Now, both these kinds of inconvenience have been avoided in a very wonderful, but simple way. The earth has been so poised in her course that her axis is a little, but not very much, inclined to her orbit. By this beautiful arrangement we have our pleasant variety in the length of our day and night. By this arrangement the northern part of our globe is inclined towards the sun for the half of our yearly revolution; and then, of course, we have longer days. During the other half of our course we are inclined away from the sun, and so we have longer nights. Those who live in the southern hemisphere, will, of course, have a similar experience. It is not very easy to make this plain without a diagram; but it is simple enough if you give it a little thought, and it will well repay thought, for it is a marvel of wise and beneficent arrangement.

Now, as we have said, the earth has another motion, besides this daily motion on her axis. She has a yearly motion round the sun. We have just referred to this in accounting for our variety of day and night. Now, the peculiar position of the earth which gives us variety of day and night, gives us also variety of seasons. And here we have a beautiful example of how

ONE GREAT LAW IN NATURE

produces different effects. The inclination of the earth's axis just referred to, keeps the northern part of the earth inclined towards the sun for six months of the year; that is, during half of the earth's course round the sun. That inclination towards the sun gives us our summer, with spring at the beginning, and autumn towards the end. Then, turning gradually from the sun, the autumn merges into winter, until we again approach the other half of the circle, when winter merges into spring. Were it not for this wonderful, but simple arrangement, in so poising the earth in her orbit, some parts of her would have excessive heat and cold, or else no variety whatever.

If you just

MAKE A SMALL CIRCLE

to indicate the sun, and draw a wide circle around him to indicate the path of the earth, and then place the earth in different parts of that circle, with her axis inclined as I have described, you will see at a glance how wonderful and beneficent is the arrangement for giving us variety of day and night and variety of seasons.

Now, just as the earth moves round on her axis with such surprising exactness as to time, so she moves round the sun with the same unerring regularity. We are accustomed to say that she moves round the sun in 365 days. But that is not exactly correct. She takes 365 days, and a few hours, and a few minutes, and a few seconds, and a few fractions of a second. The time, as near as can be computed, is 365·2564 days! Yes, and she keeps to that time without any deviation for thousands and thousands of years! Do you know of anything more astounding than that? To think of the countless millions of chances for the earth to go wrong, and

ONLY ONE CHANCE

in countless millions to go right, and yet she goes right, not once nor twice, but always!

And yet, such is the perversity of human nature, that some men will try to believe that this is done by chance. They do not call it chance exactly, for that would sound too manifestly silly; so they call it law, or nature, or evolution. This looks more learned. But what is law without a law giver, but chance? And what is evolution without an evolver, but chance? It is blind chance, dignify it by what name you will. And so, this accurate movement of the earth, for thousands and thousands of years, is supposed to come by chance! But a clock does not keep time by chance. No! a clock maker is required to make it do so, with even an approach to accuracy, and that only for a few years. Yet the earth keeps time to a fraction of a second, for thousands of years; and she does this by chance! Ah, let us beware of giving such a

LOOSE REIN TO SCEPTICISM,

which in the long run is the wildest superstition.

And yet, this surprising accuracy of the earth's movement becomes more surprising still, when another circumstance is taken into account. We would naturally suppose that to maintain such uniform accuracy, the earth must move exactly at the same rate of speed through her entire course round the sun. But, strange to say, this is not the case. Her path round the sun is not a complete circle, but an ellipse; that is, a circle flattened a little on two opposite sides. The result is, that at the flat parts of the circle she draws a little nearer to the sun. Now the sun is always attracting her towards himself, and the nearer she comes to him he attracts her the more. Therefore, when she comes to the flat part of the circle, being nearer, he attracts her more; yet he cannot draw her in; but the result is, that she moves faster until she gets farther out of his range, and then she goes slower. And yet, in spite of this disturbance in her movement, she keeps the time with unfailing accuracy. If she goes faster at two places in her course,

SHE SLACKS HER SPEED

through the rest of the course, and still completes the circuit to the fraction of a second.

Can anything be conceived more marvellous than this? We shall get far afield by and by amid countless stars and suns; but I doubt if we shall find anything more wonderful than this movement of the earth round the sun. And the marvel is not confined to the earth, but seems to be a general law in the movements of the heavenly bodies.

What amazing forethought, and wisdom, and power, are here displayed. Truly, "an undevout astronomer is mad." There is a madness of the heart, as well as of the head; and the madness of the heart is the worse insanity.

CHAPTER III.

THE MOON.

Comparatively a small globe—Phases—Eclipses—Why not oftener eclipsed—Ancient Chinese astronomy—Eclipses predicted three thousand years ago—Sublime constancy of nature—Is the moon inhabited?

WE have a far closer relation to the sun than to any other globe, and perhaps we ought to give him our next attention. But we will be courteous enough to our own moon to give her the preference. She is a very small body, and fulfils no great functions compared with those of the sun, but sails with serene purity behind our dark clouds,

GIVING A TOUCH OF ROMANCE

to our dull, prosaic world. She claims our first attention in that she is by far the nearest celestial body to the earth; and also because she belongs to us alone, sustaining almost no relation to any other world.

The points of interest regarding our moon are mainly these: Her size, her distance, her light, her motions, her phases, her eclipses, and the question as to whether she is inhabited.

As we have said, the moon is a small body; that is, compared with the earth. Indeed, among all the bodies of the solar system—that is, among all the bodies which circle round the sun—the moon is the smallest of them all. It would take fifty moons like ours to be rolled into one globe to be equal to the earth; and the earth herself is a small body compared with many others.

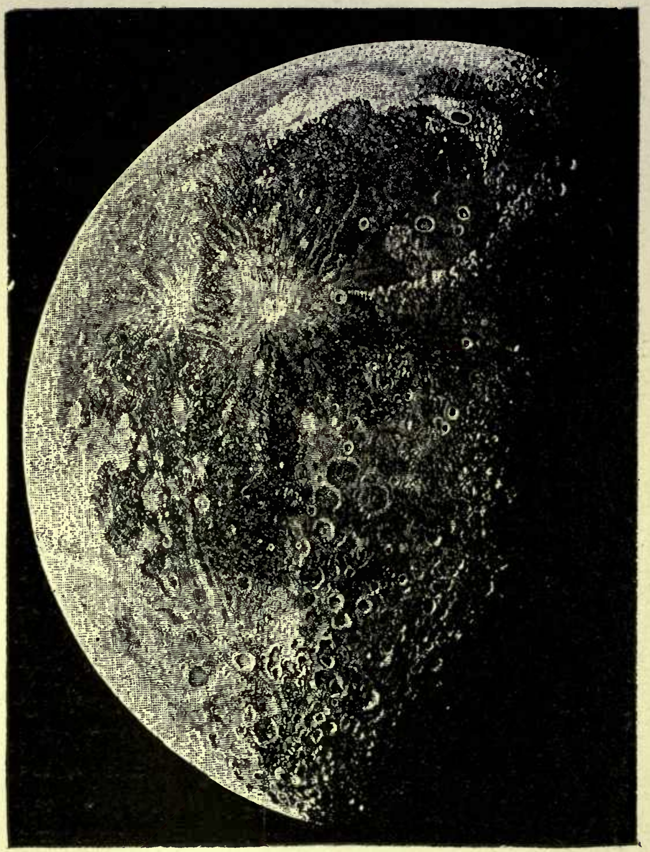
The light we receive from the moon, though so pleasant and grateful, is small. It is small for two reasons. She is but a reflector of the sun's light; and, being small, she cannot reflect a great deal. In fact, it would take

SIX HUNDRED THOUSAND FULL MOONS

to equal the light of the sun. But what we have is enough. It is intended only as a relief to our dark nights, and is a wise and benevolent arrangement.

Then, the moon has varying phases; sometimes being full, then with a little chip off one side of her, then a crescent, growing thinner every night, until it wholly disappears, and we have no moon at all. Then very soon a thin crescent appears, growing larger night by night, until we have a full, round, bright moon.

What is the cause of such changes? Why cannot the moon shine on, serene and steady, like the sun and stars? The reason is that she gets all her light from the sun, and the sun can illuminate only the one side of her that is turned directly towards him. Thus there always will be



VIEW OF THE MOON NEAR THE THIRD QUARTER.

From a photograph.

A FULL MOON SOMEWHERE,

but the illuminated side of her is not always turned to the earth, and hence is not seen. But as the moon is round, the part of her illuminated surface that we can see will appear as a crescent, larger or smaller.

These changes, then, are due to the moon's revolution round the earth. If she remained steadily in one place, and if the sun shone directly on the side of her turned toward us, we should always have a full moon. But in her revolutions she shifts gradually around to a place where no part of her illuminated disc is visible, and then we have practically no moon. If we were on the other side of her, we should see her in the full, for she is always shining somewhere.

Now as the moon makes her revolution round the earth every month, we see how it is that a month gives us all her phases, from the new moon which is dark, to the full moon which is bright, and then round again to the new moon, with the varying crescents between these two extremes. It is a simple arrangement, but it produces wonderful beauty and variety.

But now, if the moon moves round the earth once a month, how comes it that we do not have

AN ECLIPSE OF THE SUN

once a month, and also an eclipse of the moon at the same time? That is a very natural question to ask, for at the first glance we do seem to have present all the conditions necessary for a monthly eclipse, both of the sun and moon. Let us therefore look into this curious thing a little closer.

An eclipse of the sun is caused by the moon coming between the sun and the earth. When the shadow of the moon falls on the earth the sun is eclipsed to every part of the earth where the shadow falls. But as the moon comes between the earth and the sun once a month, why is not the sun eclipsed once a month? Because the plane of the moon's orbit round the earth is not parallel with the earth's orbit round the sun, but inclined to it about five degrees. This affords the moon the opportunity quite often of getting past the sun without coming directly between him and the earth. In the great majority of cases she dodges this actual conjunction, and then we have no eclipse.

Further, the moon's shadow upon which the eclipse depends is of a conical form, ending in a point. Therefore, as

THIS SHADOW HAS TAPERED

very much before it reaches the earth, it has a great chance to miss the earth altogether, and in that case there can be no eclipse. This explains, too, why an eclipse of the sun lasts so short a time, and why the eclipse is visible only in certain parts of the world. As the shadow is very small where it strikes the earth, and as the moon still keeps moving on, the shadow soon passes off, and then the eclipse is over. And the shadow being so small, it does not cover a great space on the earth, and so falls only on certain places. These circumstances, then,

PREVENT AN ECLIPSE

of the sun taking place very often. But there are times when the moon comes so directly between the earth and sun that the earth cannot escape the moon's shadow, and then the sun is eclipsed.

There is another circumstance, too, which prevents this eclipse taking place so often as it otherwise would. It so happens that the shadow cast by the moon is just about long enough, roughly speaking, to reach the earth. We have seen that the shadow has tapered very much when it gets here. But sometimes it is too short to reach the earth at all. That happens when the earth and moon are most widely apart. For the moon is sometimes farther from the earth than others. She moves round the earth in an ellipse, as the earth moves round the sun. There are times, therefore, when the moon, though in the right direction to cause an eclipse, is too far away to cast her shadow on the earth, and in such cases there is no eclipse.

Some eclipses of the sun are total, and some are partial only. And there is one beautiful eclipse called an annular eclipse, which occurs very seldom. This is

A TOTAL ECLIPSE

of the sun, except his outer rim which remains brilliant. It will be noticed, too, that the sun can be eclipsed only at the time of a new moon, because the moon being then between us and the sun, the side of her that is turned to us is dark.

Now I need not dwell at length on eclipses of the moon. These are produced by the earth coming between the sun and moon. The earth casts a shadow, just as the moon does, and when this shadow falls on the moon, she is eclipsed. But the earth, being much larger than the moon, casts a much larger shadow. The consequence is, that the moon finds it hard to escape. Also the eclipse lasts much longer, usually, than that of the sun, because the earth's shadow being larger,

THE MOON REQUIRES MORE TIME

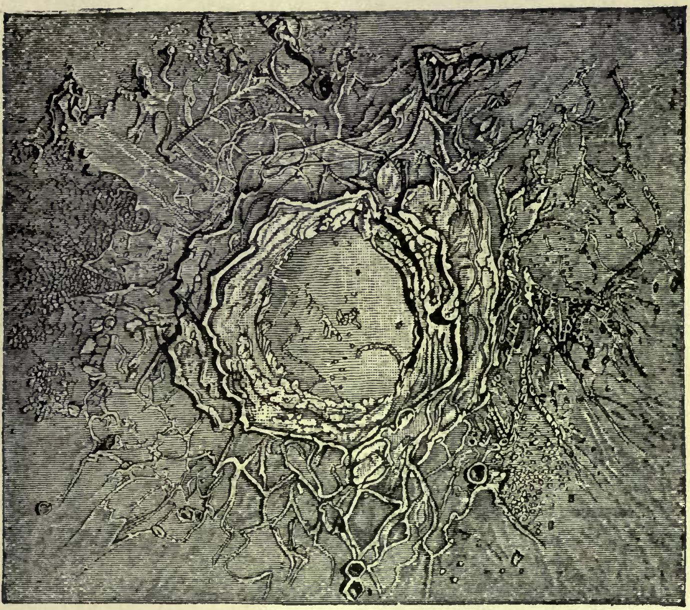
to pass through it. If the shadow happens just to touch the rim of the moon, the eclipse is partial and short. It is evident, further, that the moon's eclipse always happens when she is full. Being then in conjunction with the earth and sun, and on the outer side of the earth, her illuminated face is turned directly toward us.

These matters are not hard to understand if you give them a little thought. Time was when, in the infancy of science, eclipses were feared, as portending some terrible disaster. Now they are seen to be the operation of beautiful, divine laws.

It is interesting to know that the Chinese, whose civilization dates so far backward, were able to predict eclipses three thousand years ago. An eclipse

OBSERVED IN BABYLON

is described by Ptolemy as having occurred seven centuries before Christ. And we presume that the motions of the sun and moon on which such predictions were based, were the same then as now.



LUNAR CRATER "COPERNICUS," AFTER SECCHI.

What a testimony is this to the fact that, while civilizations rise and fall, nature, with steady, sublime movement, holds on her way.

Before taking leave of the moon we might notice one peculiar circumstance in regard to her two motions. We know that the moon passes round the earth once a month. Astronomers claim that her movement on her axis is performed in exactly the same time to a second. This is so remarkable a circumstance that I cannot but hesitate to accept it. For you will observe that there is no known or necessary relation between these two movements, whereby we could expect them to coincide in point of time. We find no approach to

SUCH A COINCIDENCE

in the case of the planets. They move on their axis. and they move round the sun, in the most diverse possible periods. That these two movements should coincide to a second is a marvel that seems entirely unnecessary, and is almost too strange for belief. And yet I believe the same thing is claimed on behalf of some other moons besides our own. The proof will need to be very clear before such a theory can be generally accepted.

Two strange effects would follow this curious circumstance, if it actually exists. It would follow that there is one-half of the moon which we have never seen. It would also follow that our earth is a large moon to one-half of our moon, and that the other half has no moon at all.

As to whether the moon is inhabited, we may say that astronomers are generally agreed that organic life, as we know it, could not be sustained there. But the general question as to the habitation of other worlds we may hold over until we have taken a glimpse at the planets which with the earth are circling round the sun. Then we may be in a better position to judge whether any of those worlds are the abodes of intelligent beings.

CHAPTER IV.

A UNIVERSE OF LIGHT AND FIRE.

The central fire—The fuel—Shovelling in moons—A celestial journey—Ambition and patience of astronomers—Motion of light and sound—Blowing a trumpet in the sun—A furnace of fire—The ultimate motive power—Niagara a drop in the bucket.

WE spoke of the moon as being closely related to us, because she is so near, and because she is our own special attendant. But we are much more vitally related to the sun, although he is 360 times farther away than the moon. He is the very life of our world. He

LIGHTS AND HEATS THE WORLD

by his rays. Not only so, but by the vegetation he called forth away in the distant past, the coal was formed which gives us additional heat and light. And his beams are so charged with color, that all the beauty of our vegetation comes from him. Then by his attractive power he holds our world in her proper path as she swings around him, else she should have long ago dashed away into space, to die with cold or to collide with some other globe. We might dispense with the moon, perhaps, and live; but if the sun's influence were suspended, this world and all the worlds on which he shines would perish.

We may suppose, then, that the sun must be immense in size, and intense in heat, to exert such power. He is both, as we shall try to illustrate.

Think, first, of the immense volume of the sun. He is reckoned to be fourteen hundred thousand times as large as this earth of ours. Now that is easily said, but it is not easily comprehended. Let us try to understand it.

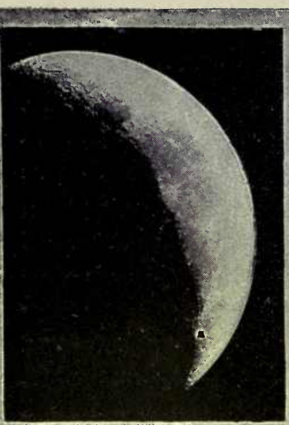
Astronomers are quite at a loss to find out how the sun's heat is sustained from age to age without getting less. One supposition is, that other bodies are constantly falling into him, as coal is thrown into a furnace, and that in this way his heat is sustained. It is not a very happy guess. We are not told where these bodies come from to feed the sun's fires. No one can imagine where they could come from.

But now suppose that the sun's heat is kept up in this way. And suppose this kind of fuel was running short, and suppose we were casting about to find some

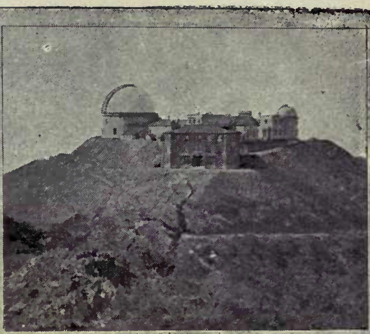
GLOBES THAT MIGHT BE SACRIFICED

to the sun, to keep up his heat. In an extremity of this kind we might, perhaps, be willing to sacrifice our moon, so that we might not die of cold. And we might ransack creation to find other moons that might be given up for this purpose. I want to know how many such moons as ours could be thrown into the sun before he would be full.

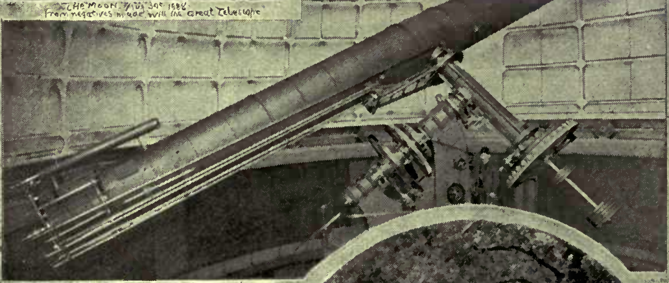
Remember that this moon of ours is no small body.



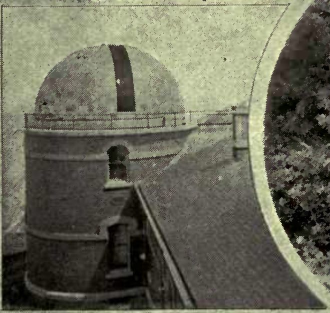
THE MOON. Aug 30th 1888
From negatives made with the Great Telescope



Lick Observatory



The "Great" 36 inch Objective Lenses



M-N-Cox North Dome Lick Observatory

Live Oak California

If you would pass a tape line around it you would find that it has a girth of six thousand miles. Well, suppose we have a pile of these moons to shovel into the sun. Imagine a mighty stoker shovelling them in. How many would he shovel in before the sun would be full? He would shovel in no less than seventy millions of moons.

But we have no adequate idea of such a vast number. Let us put the matter, then, in another way. Suppose that to maintain the sun's heat

ONE MOON WOULD NEED TO BE SHOVELLED IN

every ten minutes, and that this supply was kept up night and day. How long would it take the stoker to shovel in the seventy millions of moons? It would take him no less than 1,350 years! Now that is surely astounding. It gives us some conception of the immense volume of this universe of fire.

Or, take another illustration. We spoke of the motion of the moon round the earth. She makes this revolution at a distance from us of about 240,000 miles. Now that is a long way off. If we could go to the moon in a train, and travel at the rate of a thousand miles a day, we would have to spend eight months on the trip, travelling day and night. That shows that the moon is a long way off. But, now suppose the earth were placed in the centre of the sun. Suppose the moon were revolving round us, and as far distant from us as she is now. Of course, in that case, the moon would be a long way outside of the sun? No, not at all. There would be

PLENTY OF ROOM WITHIN THE SUN

for the moon to make her revolution. Nay, more, the moon's orbit in such a case would be just about half way between his centre and his outer rim. There would be room for an outer moon to be placed as far away from the inner one, as the inner one is distant from the centre of the sun; and even that outer moon would find space within the sun in which to revolve. Such is the astounding magnitude of the sun. He is really a universe in himself. Within his vast expanse hundreds of worlds like our own could revolve in wide orbits without any chance of collision.

I may add here a comparison between the bulk of the sun and that of the planetary worlds that surround him. Taking no account of a number of very small planets, we may say that there are eight large ones. Of these, the earth is one of the very smallest. One of the larger ones is fifty times larger than the earth; another sixty times; another a thousand times; another twelve hundred times. So these must be worlds of vast magnitude. Yet, if they were all

ROLLED INTO ONE GLOBE,

it would take that globe, and five hundred more of the same size, to be equal to the sun. I think we have now risen to some conception of the vastness of this orb of light and fire.

The next thought that naturally suggests itself to us about the sun is his distance from us in space.

Being such a universe in himself, as we have seen, and yet appearing so small, we would at once come to the conclusion that he must be immensely far away. Yes, if we had never made any calculation of his distance, we should feel that it must be immense. And the distance can be calculated. Just how this is done I need not try to explain here; it is enough that it is done, and done reliably. We may first express the distance in miles, and then use some illustrations to bring the fact more intelligently within our grasp.

It is a wonderful evidence of puny man's ambition that he ever attempted such a feat; and it is no less a wonderful evidence of his genius that he accomplished it. Even so early as the third century an attempt was made to

MEASURE THE SUN'S DISTANCE,

but neither the methods nor the instruments of that early time were equal to the task. Hence, the estimate made then was somewhere about five millions of miles only. In the seventeenth century Kepler made it thirteen or fourteen millions of miles. Later calculations brought it up to eighty millions. Not very long ago the estimate was ninety-five millions. This has been corrected, and now the ascertained distance is about ninety-one millions of miles.

It need excite no surprise that such a stupendous problem was not solved sooner. The marvel is that it was solved at all. With the imperfect methods and implements they possessed, the early astronomers did wonders. And one special hindrance to an earlier solution was, that

ASTRONOMERS HAD TO WAIT

from time to time for the transit of Venus. This was a main factor in the calculation. But this passage of Venus across the disc of the sun occurs but rarely, and thus a complete settlement of the question was delayed. You can imagine what a serious delay this might be, when I state that the next transit of Venus is not due until the year 2,004. It is fortunate for us that the question is now decided, else we might have a long time to wait.

Now it is very easy to speak of ninety-one millions of miles, but who can grasp what that means? I have read of a tribe of Indians who could count up to twenty, that number being represented by their fingers and toes. If you spoke of any number beyond twenty, they would point to the hair of their head, to signify that it was innumerable. Now we are very much in the same position, only a little farther advanced. We may speak of thousands and millions, but we cannot well conceive what a thousand means, much less a million. Hence we must try to illustrate what is really meant by ninety-one millions of miles.

Take, then, the motion of light. Nothing that we know of travels with such bewildering speed. Yet, quick as it is, its rate of motion has been calculated to a nicety. It is found that it requires

ABOUT EIGHT MINUTES

to come from the sun to the earth. But that fact, of itself, does not help us much to realize the sun's distance. Take, then, the earth into your view. This globe of ours is 25,000 miles in circumference. How long do you think it would take light to make this journey of 25,000 miles? Would it take an hour? Less than that. A minute? Less than that. A second? Less even than that. The fact is, that light would flash round this great globe of ours no less than seven times in a second! Realize, then, if you can, how immensely distant the sun must be, when light requires eight minutes to make the journey.

Or, take sound. It is easy to see that sound requires some time to travel from one object to another. If you watch a man at a distance striking any object with a hammer, you notice that the stroke is delivered a little time before you hear the sound. So, in the firing of a gun at a distance, you see the flash before you hear the report. In the same way

YOU SEE THE LIGHTNING

before you hear the thunder. The interval marks the time required for the sound to travel to your ear. It may seem quick, but it is a creeping, crawling pace, compared with the motion of light. We might say that as between the motion of sound and of light there is about as much difference as between the motion of a worm and an eagle.

Now, if light travels from the sun in eight minutes, how long do you think sound would require to make the same journey—that is, supposing sound could travel so far? It would require no less a period than fourteen years. If

AN ANGEL STANDING IN THE SUN

to-day could blow a blast on a trumpet loud enough to be heard down here upon the earth, the sound would not reach us for fourteen years. Does that help you to realize how far away in space this sun of ours must be?

Or, we may suppose you have taken your seat in that train which we started for the moon a while ago. We found that by going at the rate of a thousand miles a day, you would reach the moon in eight months. When you get there I think you will realize that you are a long way from home. In five days you could cross this broad continent of ours, but now you have travelled on in a straight line for eight months. Ah, you are a long way from home. But suppose you have courage to continue your journey to the sun. How long do you suppose you would travel at the same speed before arriving there? You would go on, day and night, for two hundred and fifty years. Ah, we are getting into the immensities now, and greater immensities await us farther on.

We are thus led, in the next place, to think of the vast amount of heat which the sun must have stored up in his depths, and which he is so lavishly giving out every day.

Like other men, astronomers do not always agree. It might be supposed, however, that there could be

NO DIFFERENCE OF OPINION

as to whether the sun is hot or cold. You would say that we do not need to be astronomers to know that he is hot. Some astronomers grant that he may be hot on the surface, but they claim that he is cool inside. Just how they know that, they do not say. Others have said that he is really cold. In the year 1798 Charles Palmer published a book in which he tried to prove that the sun is made of ice. But that man did not make many converts to his view. No matter how scientific a man might be, he cannot afford to part with common sense.

Just what the sun is made of is not very certain yet. Whether he is a gas, a liquid, or a solid, there is still some difference of opinion. We cannot be far wrong, however, in taking the common sense view that he must be very hot. Surely he must contain a vast amount of heat, to last so long; and an intense degree of heat, to reach so far.

Various ingenious calculations have been made to show something of the immense amount of heat that must be stored in the sun. Our own experience might be convincing enough. What a quantity of heat each one of us receives from the sun in one hot summer day. Then consider that each one of us is but a point in space, and that in all space the same intensity of heat is poured.

Suppose that this earth marked the limit to which the sun's heat extends. Suppose that we had a solid dome all round the sun at this distance of ninety-one millions of miles. It is evident that on every point of that dome the sun pours as much heat as he pours on yourself. It is evident, too, that not the dome alone is thus heated, but

EVERY YARD OF SPACE

between the dome and the sun. Not only so, but we are placed at the coolest part of the whole expanse, because farthest from the sun. The heat increases toward the sun, so much so that the regions near to him are a flaming furnace, ten thousand times hotter than our highest temperature here. What incalculable heat, then, must be poured from the sun every moment of time. Then add to this the thought that this expenditure of heat has been going on through ages and ages past. But now let us enlarge the dome. There are worlds much larger than our own flung out into space thirty times farther from the sun than ours; and

THOSE WORLDS HAVE TO BE HEATED

and lighted like our own. Of course, too, the space widens, and the dome is immensely larger. Yet through all this space, and over all these worlds, the sun's heat is poured. I say, how immense the quantity of his heat, to last so long; and how intense, to reach so far.

Less abstract than such suppositions are certain ingenious calculations that may give us some idea of the sun's heat. I will not answer for the accuracy of these calculations; yet possibly they are not far from the truth.

Professor Langley says that the coal fields in Pennsylvania would supply the wants of the United States for a thousand years; yet he claims that the heat so produced would not be more than the amount thrown out by the sun in a thousandth part of a second. This is an extraordinary calculation surely.

I doubt if the coal of Pennsylvania—and much less the sun's heat—can be calculated to such a nicety. Still, I would rather accept Professor Langley's estimate than measure either the coal fields or the sun's heat for myself.

Another calculation is, that the sun's heat that is poured on the earth alone would be sufficient to drive five hundred and forty-three thousand millions of engines, each of four hundred horse power. So much accuracy, again, inclines us to be skeptical. But even the vastness of the calculation and the conclusion give us a hint of the immeasurable heat concentrated in the sun.

I remember when we were boys at school we amused ourselves with a burning glass. A very small glass so concentrated the sun's rays that they set paper on fire. This concentration of the sun's rays

HAS SOMETIMES BLINDED MEN

in looking incautiously through the telescope. It is well known that Galileo and Cassini were blinded in this way. The source of their misfortune, however, opened up glorious possibilities for the world. I do not mean now the wonders which the telescope reveals, but I mean the possibility of getting our power ultimately from the sun. It is possible to construct a large burning glass by which a most intense heat is procured. One glass of this kind that has been made brings the earth practically within twenty-five thousand miles of the sun. The heat thus developed melts the hardest substances known to us, such as agate, platinum, diamond, and so on. In this direction, it seems to me, will yet be found the motive power of the world.

And so, from the theoretic we get down to the practical. A vast deal of the comfort of the world depends on getting a ready and adequate supply of light, heat and power. And the world has many sources from which these things can be procured. We have gone through quite an evolution in our application to various sources of supply. Our most primitive experience was in

CUTTING DOWN OUR TIMBER,

and turning it into light and heat, and later into power; and we are not quite through that epoch yet. Then there was a very early attempt to use water power. It had a very simple application at first; now we see its latest and grandest development in Niagara. Then we called on the wind to grind our corn, and waft our ships across the seas. Then came the great era of coal, which may last a long while yet. Then from coal, gas was evolved; and later, taken ready made from the earth. Then petroleum gave us a new departure, and in many directions is supplanting coal. The tides, meanwhile, have been appealed to, but not with great success. Greatest of all so far, is the era of electricity, the most mysterious and powerful thing that man has handled yet. Or possibly radium may rank with electricity in point of mystery. of this, more later on.

But is electricity the final thing? Is it our last and completest motive power? Is there not one other greater and grander force than any that we have yet harnessed to our will? May not our last resource be the sun himself? If he can only be utilized

HE WILL DWARF AND BEGGAR

all the other forces of nature. Even Niagara, which contains wonderful possibilities, is only a drop in the bucket, compared with the potentiality of the sun. Indeed, this figure might be taken almost literally; for if the sun were a large turbine wheel, all the Niagara cataract would only be a drop in one of his buckets.

And thus the world moves on, till that day when the sun himself shall grow dim with age, and nature shall sink in years. One thing then shall still survive —the immortal spirit of man, which is superior to all material force. Man himself is the supreme wonder. He will survive, "unhurt amid the war of elements, the wreck of matter, and the crash of worlds."

CHAPTER V.

SOURCE OF SOLAR HEAT.[1]

Astronomers puzzled—Is the sun losing his heat?—What are his sources of supply?—Various conjectures—Radium—A child's solution—Realm of mystery and reverence.

THERE is nothing, perhaps, that has puzzled astronomers more than to account for the maintenance of the sun's heat. So far, there is no satisfactory solution of the problem. The following facts have to be recognized. There is, first, the incalculable amount of heat thrown off by the sun every moment. Then there are the ages and ages during which this expenditure of heat has been going on. Then, there is no evidence that the sun is at all cooler than he was in the earliest ages of history. Along with this, we have to remember that

HEAT CANNOT ORIGINATE ITSELF;

it must be created, or in some way be developed. Then how is the sun's heat maintained? It is not surprising that such a problem baffles the ingenuity of astronomers.

I know it is generally assumed that the sun's heat is waning. I say it is assumed, for it really cannot be proved. It is simply assumed by astronomers, because they can discover no method by which the sun recoups himself, to balance his constant, enormous loss. It is concluded, therefore, that he must be undergoing a process of cooling. Now this does not appear very scientific, for there may be sources of renovation of which we are not aware. Until we are sure that there are no such sources of renovation, or until we have positive evidence that the sun is actually cooling, we ought not to be too positive in our conclusions.

Some astronomers, to be sure, are more positive on this point than others. Sir R. S. Ball, for instance, tacitly assumes that the sum of the sun's heat is waning. To account for the fact that this is not perceived, he adopts the theory that the sun is undergoing a process of contraction. It is supposed that by this means he keeps

AS INTENSELY HOT AS EVER,

but that the volume of his heat is decreasing. But Sir R. S. Ball appears to have a weakness for certainty in his conclusions when there is not solid ground for certainty; and this is a weakness of some scientific men. Naturally they are on the quest for certainty, for science means certainty; but there are many things in this life which will never get beyond the range of probability.

Lord Kelvin's attitude toward this question of the sun's waning heat seems more moderate and reasonable. He believes the sun is losing his heat, and must ultimately die except he is replenished; and he says he knows of no means whereby the replenishing is effected. So, with varying degrees of positiveness, astronomers are generally of opinion that the sun is on the way to extinction. And this conclusion is reached, as I have said, not by any evidence of diminishing heat, but because no means of replenishing the constant loss can be discovered.

But astronomers did not take this ground hastily, for I think they must have felt that it is not very solid or scientific ground to take. So they taxed their ingenuity to discover, or if not to discover, to invent, some way of maintaining the sun's normal temperature. I say invent, for I suppose

ABOUT TEN CONJECTURES

of this kind have been launched by different authors. Certainly a theory does not seem to be in a good way that needs so many conjectures to sustain it. And these conjectures are for the most part so far fetched that, if they do not meet the case, they show the need of some more probable theory, or else a change of ground.

I believe the idea of contraction already referred to is the explanation most generally adopted. But this theory is set forth, it seems to me, with too much certainty and completeness. Having espoused the theory of contraction, Sir R. S. Ball must needs be so definite that he can tell us just how many feet the sun contracts in a year. He says the sun contracts just about 220 feet! It is a great triumph of genius, surely, to be able to say that

A UNIVERSE SUCH AS THE SUN,

880,000 miles in diameter, and 91,000,000 of miles distant, contracts just about 220 feet in one year. This is a little too exact for me.

Another remarkable conjecture is, that the sun keeps up his heat by rubbing against the ether! I think the originator of this theory ought to get the prize for ingenuity, at all events. If astronomy has done nothing more, it has certainly opened up a wide field for imagination. But astronomy, of all sciences, should be held to its great mission of demonstration.

Another favorite theory, to explain the sun's constant heat was, that globes kept constantly falling into the sun as fuel, and that thus his heat was kept up to par. But the author of this view did not tell us where these globes come from, or if there is a large supply of them, or how they happen to fall into the sun so regularly. Such mere guessing seems unworthy of men devoted to the sublime science of astronomy.

Now, as I have said, the contraction theory is the one most generally adopted. But there occurs to me just now an objection to that theory which, so far as I know, astronomers have not anticipated. If the sun is actually expending his fires without being proportionately replenished, he must be losing his density, and losing therefore his attractive power. How then must it fare with the planets depending on him to keep them in their exact orbits? Will they not be

DEFLECTED MORE OR LESS

from their true course? I think they must. But is there any indication that they are swerving from their appointed course? If there is any deflection here, it could soon be detected, since the planets accomplish their revolutions with such astounding accuracy. But there is not the least indication of any such deviation from their course. Must not this theory of contraction, therefore, be consigned to the limbo of other vain conjectures?

Singular to say, since writing the above, there has been a remarkable scientific discovery, which goes a long way in justifying my scepticism of the various theories regarding the sun's waning heat. It has been found that the lately discovered substance called radium gives off heat without combustion or deterioration. This strange discovery must modify all preconceived ideas as to the production of heat and other forms of energy. Heat without decomposition has been regarded hitherto as a chemical impossibility; now it would seem that there is no such impossibility. For aught we know, therefore, the sun's heat may be maintained without contraction or any known cause whatever. If he only possesses the quality of radium, it would seem that he may go on expending his heat forever without diminution, and without recouping himself from any known source. Who knows whether he may not recoup himself from some source hitherto unknown? At any rate, this is a strange discovery. If it can be verified beyond all peradventure, it may well teach us to be cautious in arriving at conclusions. We really know but a very little of the whole scheme of the universe. Hence our induction is often far too limited. And in this case, supposing the new theory to be fully verified, the difficulty of applying it to the sun will probably remain, and so the problem of accounting for his sustained heat may still continue unsolved.

I may say here that when I was a child I had thoughts about this very problem. And my childish thought then was, that the sun's heat came direct from the divine Creator Himself. Perhaps it was but a childish fancy ; yet may it not be as near the mark, possibly, as some scientific conjectures ? For if we give these conjectures all they claim, they only remove the problem one stage backward, where we merge into a deeper mystery. For if we find even an adequate cause, we want to find another cause behind that, and another, and another, until we get back to the First Cause. Then we have the divine solution.

In the meantime, there are places where it is both more scientific, as well as more reverent, to say, " I don't know " ; or as the inspired Psalmist would say, " It is high ; I cannot attain unto it."

CHAPTER VI.

FATHER SUN AND HIS FAMILY.

Order and beauty—Eight large globes—A family of worlds—The sun's children and grandchildren — Prodigals in the family—Erratic wanderers—Immensity of Neptune's orbit—Varying periods of revolution—Necessity of reverence in astronomy.

SO far, we have been thinking of the sun as a vast universe of fire. We have been trying to realize something of his immense size, of his intense heat, and of the means by which that heat is sustained from age to age. We have been calculating, too, his immense distance from us. We might wonder why he has been placed so far away; but

THEREIN LIES OUR SAFETY;

for if we were much nearer, our world would have been burned to a cinder long ago.

We are thus led to think of the sun's relation to our own world, and other worlds like ours; for there is a beautiful unity, and plan, and system in the arrangement of these globes. If the stars had been flung out at random, to career through space wherever chance might drive them, we may imagine something of the wreck and ruin that would have ensued. Suppose that from every port on the Atlantic ocean, both east and west, steamers were to sail without chart, or compass, or captain, to go wherever they might be driven by wind or tide, can you imagine the collision and destruction that would result? On a far vaster scale

CHAOS AND HAVOC

would have reigned among the stars, had their movements not been appointed and controlled by a directing Mind and an omnipotent Hand.

We wish, therefore, to take a glance at the order and beauty of one portion of the starry heavens. Let us take a survey of the solar system. We select this part of the heavens for two very good reasons. We are most directly interested in this system of worlds, because our earth is one of these worlds herself; and then, we can know much more about the worlds of this system, because they are the nearest to us of all the starry hosts.

Now the solar system is a system of worlds controlled by the sun. The sun himself is the centre, and around him they all revolve. These revolving globes are the planets, and our earth is one of them. Then certain of the planets have satellites or moons revolving around them, as they themselves revolve round the sun. Our earth has one such moon, while other planets have

TWO, OR FOUR, OR EIGHT MOONS;

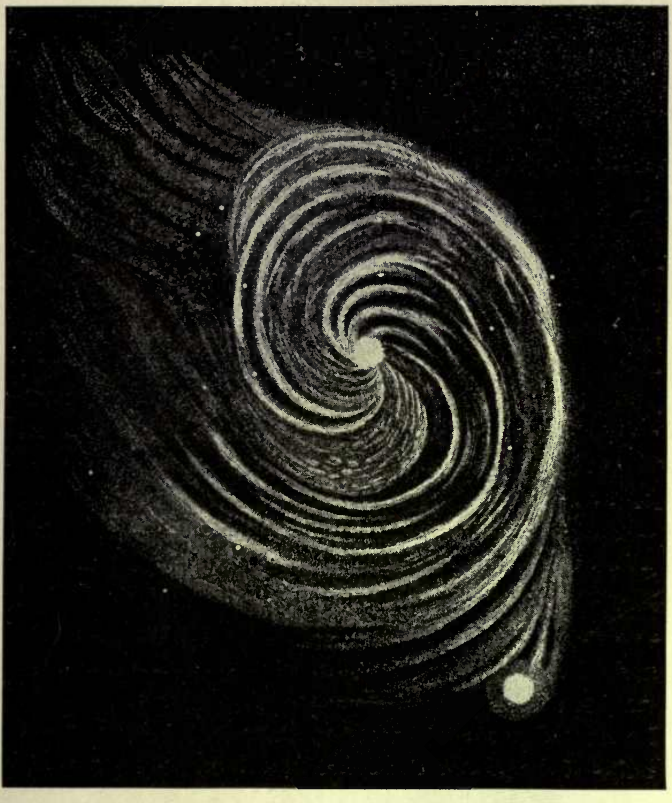
and others, again, have none. The planets vary very much in size, in their distance from the sun, and in the time in which they make their revolutions. We might say, in a loose way, that there are about a hundred of these planets revolving round the sun; but many of them are very small, and are not usually taken much notice of. There are eight globes that we might call quite large, but these again differ very much in size. It will be sufficient if we give a little attention to these eight globes, and their moons; and also, of course, to the sun, which is the central body of all.

Thus we have here a family of worlds. The sun may be regarded as the father; the eight planets are his eight children; and the moons, the children of the planets, are the sun's grandchildren. This relation exists in a very real way, too, if the nebular hypothesis is true. For, according to this theory, the planets are actually parts of the sun himself. It is supposed that

HE PARTED WITH THEM,

one by one, a long time ago; so that in an almost literal sense they are his children. It is believed, again, that just in the same way, the planets parted with bits of themselves which became moons, or children of the planets, and therefore grandchildren of the sun. Thus the idea of a family of worlds is sustained with almost literal exactness.

This analogy might be carried even a little farther. Besides planets and moons there are comets. These may be regarded as the prodigals of the family. In



THE SPIRAL NEBULA M 51 CANUM VENATICUM.

(Earl of Rosse.)

many ways they are very like prodigals. Their course is very erratic. They seem not content to stay within the bounds of the home system, as the planets do. And when the comets go off, they go off a long way. No one knows where they go. Their wanderings, except in a few cases, cannot be traced. Then there is no certainty as to when they may be expected back. Some do come back, after a long and uncertain interval; and some never come back at all. Then, as a rule, if they do return they never stay long. A comet will course around the sun, and come so close to him that you would think it would be detained, and

NEVER BREAK AWAY

again. But it dashes off from the sun's embrace, and swoops out into unknown regions once more. In fact, the comets seem to disregard all the established rules of the family. To me it has always seemed doubtful if they belong to the family at all. They are very unlike the other members of the family, and they have none of their sober and settled ways. So these

ERRATIC WANDERERS OF THE SKY

may be taken as the prodigals in this family of worlds.

I have said that there are eight globes specially worthy of notice in this planetary family. Let us name them in their order of nearness to the sun, and indicate how far each one is distant from him :

Mercury	is distant	from the	Sun	35	millions of miles.
Venus	"	"	"	66	"
Earth	"	"	"	91	"
Mars	"	"	"	139	"
Jupiter	"	"	"	476	"
Saturn	"	"	"	872	"
Uranus	"	"	"	1,754	"
Neptune	"	"	"	2,746	"

I have named the planets in this order, chiefly that they may become familiar to you in their positions and relative distances from the sun. I am conscious that in quoting the actual distances in miles, no adequate idea of the facts is conveyed; the distances are far too vast to be realized.

You remember how amazing is the sun's distance from the earth, as we tried to illustrate it. We found that light, which would go seven times round the earth in a second, would require eight minutes to come to us from the sun. But you see that Neptune is thirty times farther distant from the sun than the earth is; therefore light would not pass from the sun to that planet in less than four hours. We found, too, that a fast railway train would not reach the sun in less than 250 years; but the same train would not get to Neptune in less than seven thousand years.

The orbit of Neptune represents the area occupied by the solar system. Try in imagination to look across that orbit. You were dazed in trying to realize the distance of the sun, but here is a distance vaster far. If one person could speak to another

ACROSS THE ORBIT OF NEPTUNE,

the words would not be heard on the other side of the orbit for 850 years. What vast spaces we have to do with here. How the universe widens. There begin to dawn upon us suggestions of infinity.

Now the next thing is to get some idea of the different sizes of these planets in our system. There are some interesting facts here which may be grasped more readily if I quote the diameters of the planets in miles.

The	diameter of	Mercury	is	2,962	miles.
"	"	Venus	"	7,510	"
"	"	Earth	"	7,912	"
"	"	Mars	"	4,920	"
"	"	Jupiter	"	88,390	"
"	"	Saturn	"	71,904	"
"	"	Uranus	"	33,024	"
"	"	Neptune	"	36,620	"

I think the first thing that will strike you here is, the great variety in the size of these globes. They vary from Mercury, about three thousand miles in diameter, to Jupiter, nearly ninety thousand miles. It would take fifteen globes like Mercury to be equal in size to the earth; but it would take twelve hundred earths to be equal to Jupiter.

The next thing you will notice is, that the earth is one of the small planets of the system. Venus is just a little smaller; and the only others that are considerably smaller are Mercury and Mars. But then look at the other four immense globes. The earth is insignificant compared with one of these. In fact the earth is hardly large enough to make a decent moon for Jupiter or Saturn.

There seems to be some kind of approach to a law, in the varying sizes of these planets. You will notice that the four inner ones are decidedly small, and the four outer ones decidedly large. The law of increase holds as we proceed outwards; but it does not hold with exactness. It applies in the case of the first three, Mercury, Venus, and Earth; then the next one, Mars, is smaller. After Mars, there is

AN IMMENSE STRIDE TO JUPITER,

in regard to size; the remaining three, Saturn, Uranus and Neptune are all of vast size, yet much smaller than Jupiter; and the law of decrease in size holds in the case of the outer three. Thus the four inner planets are small, and the four outer ones large, with a wide chasm of separation between the two groups. I note the curious fact, not chiefly because it may be suggestive of some unknown law, but rather that it helps to give us a concrete view of the entire solar system.

All these globes revolve round the sun, and all in the same direction; but the periods of their revolution are as varied as their size, and their distance from the sun. It would be expected, of course, that those more distant from the sun should take more time to make their revolutions, their orbits being so much wider. Such is actually the case. There is a steady law of lengthening the planetary year as we proceed outward from the sun; from Mercury, whose year is only 88 days, to Neptune, whose year is equal to 160 of our years. The earth's year, as well known, is 365 days.

At the same time, it is to be noted, that the actual velocity of the planets in their orbits, grows steadily less as we proceed from the sun outward. Thus Mercury, the nearest to the sun, moves at the rate of 105,000 miles an hour; while Neptune, the most remote, moves at the rate of 12,000 miles only. This is due to two causes. First, the sun acts with greater power of attraction on the bodies that are near him; but as

HE CANNOT DRAW THESE BODIES IN,

he causes them to rush round him with greater speed. And then, in this case the outer bodies are the larger ones, and the sun cannot drag them around him so quickly. Hence the increasing planetary year, as we proceed outward from the sun, caused both by the wider orbits and the slower movement of the planets.

Let us also remember that all these planets revolve on their axes, after the same manner as the earth. But here we meet with a strange and unaccountable thing. It might be expected that there would be some kind of proportion between the speed with which a body moves round the sun, and the speed with which it moves on its axis. But there seems to be an actual disproportion here. Mercury, that moves round the sun at the rate of 105,000 miles an hour, moves on her axis at the rate only of 396 miles an hour at her equator. On the other hand, Jupiter, that moves so much slower round the sun, moves on his axis 28,000 miles an hour at his equator. Ponderous as Jupiter and Saturn are, they turn round on their axes once in each ten hours. This striking want of proportion in the case of the planets is one reason why I took leave to doubt that the moon performs her two revolutions exactly in the same time to a second.

To be sure, we may well suppose that in the movements of these mighty orbs we shall find many things which we cannot refer to any fixed law. At the same time, we see so many wonderful instances of adaptation that we feel assured that wisdom has ordained all. The reverent, as well as the scientific, spirit is necessary to the right study of the sublime facts of astronomy.

CHAPTER VII.

PLANETARY APPOINTMENTS AND SURROUNDINGS.

Day and night—Years—Seasons—Atmosphere—Sun's light and Heat—Brilliancy and color—Stages of transition—Moons of Uranus and Neptune—Distribution of Moons—Beneficent Design—Magnificence of Saturn.

WE would now take a glance at some of the conditions of the planetary worlds, and notice some of their appointments and furnishings. Hitherto we have regarded them only as globes; let us now think of them as homes. The question as to whether they are really inhabited will come on later. Just now we may look at some of the circumstances that may fit or unfit them to be the abode of intelligent beings.

We have seen that all of these worlds turn on their axes. That means that they turn to and from the sun, and, hence must have day and night. Whether the globe be large or small, the sun can light up the half of it that is turned to him, and he must leave the other side in darkness. Therefore, these worlds must have day and night. There is quite a difference in the length of the day and night in different worlds; but

THE GENERAL LAW

prevails in them all. Now, as in our own world, so in others, the day suggests activity, and the night repose.

Again, each one of these planets has its own year. Some of them have a shorter, and some have a longer year than ours; but each one of them has its own particular period. What is more, the time is kept in them all with the same amazing exactness as in our own. And this is the more wonderful when we conceive of the vastness of an orbit, say, like that of Neptune. The vaster the orbit the more chance there is for failure or mistake; but there is no failure or mistake in Neptune any more than in our own favored world.

Then, there must be seasons in the other planets, as in our own. These globes are poised more or less in the same manner as the earth; hence,

THEY MUST HAVE SEASONS,

more or less defined, as we have. We do not say that such seasons directly imply, but they do suggest, a vernal spring, a glowing summer, and a golden autumn. The seasons may vary very much in detail, but the conditions are there to produce them in some degree.

Then it is believed that all these planets have an atmosphere. This is not certain in the case of them all, and the character of the atmosphere is not in all cases ascertained; but it is probable that all of them have an atmosphere of some kind. This gives the suggestion both of animal and plant life in those distant worlds.

Further, each one of these planets is heated and lighted by the sun. Possibly there is more variety here than in any other respect. We have seen that there are immense differences in their distance from the sun. Therefore, supposing their atmosphere to be about of the same character, there will be

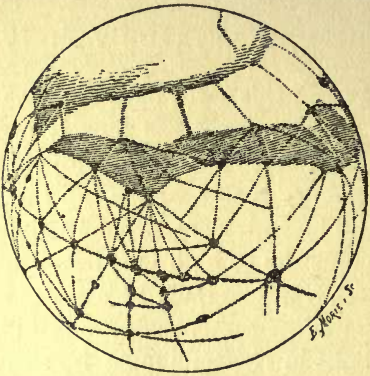
THE MOST EXTREME VARIETY

of climate. We on this earth have a pleasant moderation in this respect. But see how it is with other worlds. Take the two extremes of Mercury and Neptune. Mercury is so near the sun that it must be a ball of white incandescent fire. In that world the temperature must be so high that iron will melt. On the other hand, Neptune must be a zone of frost more intense than any instrument of ours can measure.

And the light in Neptune must be a dull twilight. It has been calculated that Neptune receives thirteen hundred times less light from the sun than comes to the earth. Imagine, then, what a dim and dreary world that must be. The stars are seen there by day as well as by night. In fact, the sun himself is discerned only as a star, and is likely not distinguishable from other stars. This earth of ours has never been seen from Neptune, and has never been suspected to exist. Possibly the immense world of Jupiter is not even seen there. And in telescopes would be of no use, the light being so dim; so it must be impossible to make astronomical observations.

These are startling conditions that we are supposing to prevail in those worlds of blazing heat and frigid cold.

These remarks, however, are subject to the qualifying condition we named a little while ago. The atmosphere may be of such a character as to modify such extremes in a very large degree. We know how the conditions of the atmosphere in this world can give us a warm day in winter, and a cool day in summer. It is believed that the atmosphere on the planet Mars is much rarer than ours, and that the temperature in that world is much colder. So it is not the distance of the sun alone, but also the char-



TELESCOPIC ASPECT OF MARS.

acter of the atmosphere that determines the temperature. And the effect may be much greater where it is more needed; so that both Mercury and Neptune may not be nearly so extreme as at the first glance we might imagine.

We may note the fact also, that some of the planets differ very much in brilliancy and color. We are all familiar with Venus, the evening star. When seen at her best, she is the brightest star in the sky. What may be the cause of

HER PECULIAR BRILLIANCY

we do not know. There is probably something in the constitution of her atmosphere specially favorable for the reflection of the sun's light. Then, on the other side of us from Venus we have "the red planet Mars."

The silvery appearance of Venus, and the ruddy appearance of Mars, seem to indicate that these planets are in a state of transition. Indeed, it is believed that all the planets are in such a state. It is generally supposed that all of them were originally masses of very hot vapor, and that now they are cooling into solids. Thus they would be in various stages of transition, as the large bodies require longer time to cool than the smaller ones.

We may take four globes to indicate four phases of this cooling process. Take the sun. As yet he is in the first stage. It is believed that he is cooling as surely as any of the planets, but that his mass is so large, and

HIS HEAT SO INTENSE,

that he has not got yet beyond the stage of vapor. Then take Jupiter as an example of the next stage. The surface of Jupiter seems to be partly gaseous and partly liquid. Being by far the largest planet, it is reasonable to expect he would be the slowest to cool. He may be regarded, indeed, as being midway between being a sun and a planet. It has been beautifully said of him that, "he may be a decaying sun or a developing earth." Thus he marks the second stage of transition.

Our earth is an example of the third stage. We have clearly passed the vapor stage; but we have not reached the solid stage. We have cooled so far as to have a solid crust on our surface, but we have

SURGING SEAS OF FIRE

underneath. Nor is our crust itself quite solid yet Only call to mind that late terrific eruption of Mount Pelee, and you will realize that our globe is not yet too solid or safe. So the cooling process seems very slow. Yes, it will take our earth a long time yet to get cool from the surface to the centre.

Our moon may be taken as an example of the last stage. It is believed that she has gone through the cooling process, exactly as the earth is doing, but that she has reached the final stage of being a solid, and that all her heat has departed. Considering her small size—only one-fiftieth as large as the earth—you can account for her cooling so rapidly. First she began as a puff of hot vapor; then in time became liquified;

later formed a solid crust on her surface; and finally cooled into a solid.

Such is the process that is held to be going on in the case of the sun and all the worlds that surround him. I do not quite commit myself to this theory; but it is interesting, and I admit it may be true.

The reference just made to our own moon leads me to notice the distribution of moons among the various planets. It is believed that as every planet was originally a puff of vapor cast off by the sun, so

EVERY MOON WAS CAST OFF

in the same way by a planet. We might expect, in that case, that the larger planets would cast off the larger moons, and perhaps more of them. We might expect, too, that the planets that revolve most quickly on their axes would act in a similar way. This law seems in general to have been followed. It must be remembered that some of these moons have only recently been discovered, and there may be others to discover yet. There are three circumstances that operate against the discovery of moons. First, they are comparatively small; then, as in the case of Uranus or Neptune, they are very distant; also, as in the case of Mercury and Venus, some of them are hard to find in the exceeding brightness of the sun. We may well suppose, then, there may be many moons which we shall never see. Taking the planets in their order from the sun outwards, this is the way they are accommodated with moons, so far as yet known:

Planets.	Moons.	Planets.	Moons.
Mercury	0	Jupiter	5
Venus	0	Saturn	8
Earth	1	Uranus	8
Mars	2	Neptune	2

It will thus be seen that our earth has no important or distinguishing place, so far as lunar accommodation is concerned. So far as we know, she is the only globe that has but one moon, and this is a very small one. The earth herself is one of the small planets but her moon is fifty times smaller. And we may be sure we have but one moon, for had there been more they are certainly too near to elude our search. Mercury and Venus are more likely to have moons undiscovered, because in looking for them we have to contend with the dazzling glare of the sun. It is only lately that Mars was known to have any moon; now he is found to have two. Jupiter was long supposed to have but four; but a few years ago a fifth was found. These moons of Jupiter, like himself, are of vast size. Saturn, too, has large moons, being himself a large planet; and he has eight of them shining in his firmament. Of the eight moons of Uranus, two were discovered quite recently, and he may have more. Neptune, some time ago, was not known to have a satellite at all. Then one was discovered; afterwards another appeared; but it was some years before the second was generally accepted.

It is worthy of notice, I think, that the more distant the planets are from the sun, the better they are furnished, generally speaking, with moons, both in regard to number and size. A while ago we referred the larger sizes and number of moons to the capacity of the larger and

MORE SWIFTLY REVOLVING PLANETS

to throw off more moons, and larger ones. That may be the physical law that accounts for them. But may there not be a moral law as well? The larger planets that have the most and largest moons, are the planets that have been thrown out the farthest from the sun. Those planets, therefore, need more lunar accommodation; and we see that such accommodation is provided. Take a glance again at our table of planets and moons, and you will be struck with this fact. Is there not in this arrangement a hint of beneficent design?

Before leaving these moons of our planetary system, there is one very remarkable thing to be noticed. We have said that all the planets move round the sun in the same direction; that is, from west to east. Not only so, but their motion on their axes is in every case in the same direction. We would expect, therefore, that

ALL THE MOONS OF THE PLANETS

would revolve in the same direction; and this is true, with two notable exceptions. The moons of Uranus and Neptune are found to have a retrograde motion; that is, they move in a contrary direction to that of all the bodies in the solar system. This is truly astounding; but it seems to be well verified, and it is utterly unaccountable. The great mystery lies in this, that whatever force it was that sent the globes moving in one direction, some other force should send these moons revolving in a contrary way. This one circumstance seems quite to upset the nebular theory, as we shall notice later on.

But we were speaking of the special appointments of the planets; and there is one planet which calls for special attention because of its unapproachable magnificence. This is the planet Saturn. Of all the worlds in the solar system this one stands supreme. We sometimes think this world of our own is beautiful. In the splendor of the setting sun, when the clouds in the western sky

BURN LIKE RADIANT THRONES,

we sometimes catch a hint of the beautiful, better land. Or, on a sweet and solemn night, when the moon rides so serenely through the white clouds, our hearts are touched with a strange spirituality and tenderness, and we think of the homes of eternal peace beyond the stars.

But this world at its best gives us a poor idea of the glory of Saturn. Except Jupiter, this is the largest planet in our system. Then imagine two immense moons blazing in his firnament; imagine four; imagine six; imagine eight. Of these moons some may be in the crescent, and some may be full, in the same sky; and they may be of different colors.

More than all, this world is encircled by a number luminous rings, such as are not seen in any other world we know. How many of these rings there are, we are not sure. It was long thought there were but two; now it is known that there are three; and there may be more. These rings encircle the whole globe. They are of vast size, and of different colors. Imagine, if you can,

THE GLORIOUS SCENERY

of that favored world. Its splendors must be such as we associate with the habitation of the blessed. Such a world as Saturn seems a very Paradise, where the redeemed of the Lord might walk, where angels might soar and sing.

CHAPTER VIII.

A FAMILY OF WORLDS.

Family of worlds — The family bond — Mutual attraction — Discovery of Neptune—Constancy of law—Safety in speed — Balance of planetary forces — Deflections rectified — Divine personal control.

WE have spoken of the sun and the planets that surround him as a family of worlds. What is the bond that holds this family together? For ages and ages past—it may be for millions of years before history began—this family has held together. And they have not kept united by staying in one place. We may speak of the sun in this connection as being stationary; but all the planets

HAVE BEEN WHIRLING THROUGH SPACE

with immense rapidity. Yet they are all in their proper place to-day, and are bound together in the family bond as a whole. We want to know what is the bond of union that holds this family together.

We are not considering the comets in this connection. We spoke of them as the prodigals of the family. They are the erratic wanderers of the sky. They do not stay long at home, but dash away into space no one knows how far; and we cannot tell when they will come back, or if they will come back at all. We shall give these comets some attention later on. Just now we are thinking of the steady members of the family—the sun, the planets, and the moons—and we wish to notice the bond that holds them together.

This family bond is attraction. We need not stay to discuss here what attraction really is. It is a great mystery. We do not even know whether it is a substance or merely a force. I believe myself that it is a substance, perhaps as fine as ether. At any rate it is force. There can be no mistaking that fact when you see the needle leaping to the loadstone. Now it is the same kind of force that holds the worlds together. There is this difference, however, that while the loadstone attracts only iron, all the worlds attract each other. The general laws that govern their attraction are: That the weightiest body has the most power, and it acts most powerfully on the bodies that are nearest. Thus

THE ATTRACTIVE FORCE IS RELATIVELY THE SAME

everywhere and always, so far as we know; you can calculate upon it being uniform; it simply varies according to the weight and distance of the various objects that act upon each other.

This law of attraction in the physical world is very like the law of love in the moral world. And we use the same word quite often to express the two things. We say we are attracted to such a person. There is

AN INVISIBLE BOND

that draws heart to heart, as world is drawn to world. The main difference is, that we are spiritual rather than mechanical; and so we are drawn to some, and not to others. But the worlds draw each other mutually; they are mechanical, and have no preference or choice in their attraction.

It is easy to see, then, why objects fall to the earth. An apple, detached from a tree, drops to the ground, because its attraction of the earth to itself is about nothing as compared with the earth's power to draw it down. And it was just the falling of an apple in this way that suggested to Newton the wonderful, universal law of gravitation. The very same law that causes the apple to fall keeps these mighty globes in their proper place, as they swing through ages and ages round the sun.

In looking at this great law of attraction in our solar system, we give special prominence to the sun's attraction of the planets, rather than their attraction of him. And this is the prominent thing for two reasons. First, there is the sun's immense bulk. We saw that it takes 1,400,000 globes like the earth to be equal in bulk to the sun. You can imagine, then, how little we can attract the sun in proportion to his influence upon us. Even the largest planets have comparatively little influence upon the sun; for he is 500 times of greater bulk than them all combined. Thus, the main factor in keeping these planets in their place is the sun's powerful attraction of them, owing to his vast bulk.

Then there is another circumstance that makes the sun so largely master of the situation. The planets that move round him at no one time can act in unison, and pull on the sun together. If they could, they might

DISTURB THE EQUILIBRIUM

of the whole system. As, however, they all move in their own orbits, and at varying rates of speed, they are always scattered round the sun in various directions. The effect of this is, that, pulling on the sun from different quarters, they pretty nearly counteract each other's force, and thus the sun's force remains practically intact.

We might note, too, another circumstance that aids the sun's attraction. He turns round on his axis in the same direction in which the planets move around him. This harmony of movement must make his work somewhat easier. He is the father of the planetary family, and so can rule with better effect when all the members of the family act in harmony.

This movement of the sun on his axis was discovered fifty years before the discovery of a similar movement on the part of Venus, Mars, and Jupiter. Although the sun is more distant than these planets, the discovery of his axial rotation was easier. The spots on the sun, which have

SO MUCH PUZZLED ASTRONOMERS,

turned out to be useful in making this discovery. Appearing at regular intervals, it came at length to be realized that their appearance is due to an axial revolution of the sun; and it is found that he makes this revolution in about twenty-five days.

We have spoken of the constancy of this great law of gravitation. A notable illustration of this was furnished by the discovery of Neptune. I think this discovery may be taken as almost the greatest tribute ever paid to the constancy of nature, and the power of human genius.

Frequent observations of Uranus—the planet next to Neptune—showed that in a certain part of his orbit he was disturbed in an unusual way. But no cause could be found for such disturbance. At length it dawned upon a certain astronomer that there must be some other body lying in a certain direction outside of Uranus, which must be disturbing his movement. This conviction grew, and by further observations the very region in space was indicated where the disturbing body might be looked for. Astronomers believed that such a body would be found. They were actually

IN QUEST OF A NEW WORLD.

"We saw it," Sir John Herschel beautifully says, "as Columbus saw America from the shores of Spain." And like Columbus, the astronomers were rewarded. In the year 1846 two astronomers, acting independently and in different places, made the grand discovery. We think the palm is equally due to both. The two men who thus immortalized themselves were Professor Adams, of Cambridge, England, and M. Le Verrier, of France.

While we are on this subject of the constancy of nature, I may give another illustration of a similar kind to the one just referred to. I must ask you to come out for a moment into the region of the fixed stars. These are thousands and thousands of times farther distant than Neptune; yet a discovery was made there very much of the same character. The very bright star Sirius was found to be somewhat irregular in its motion, and it was suspected that this must be due to the action of some other star not very far away, but as yet undiscovered. It was

A HAPPY SPECULATION,

for in the year 1862 a companion star was found to be moving round Sirius; and this was the cause of the disturbance. Unlike the discovery of Neptune, however, which was eagerly looked for, the disturber of Sirius was discovered, as we might say, by chance. Mr. Alvan Clark, in testing a new telescope just made in Chicago, happened to turn the telescope towards Sirius, and discovered the new star. In a sense this was a more brilliant discovery than that of Neptune, inasmuch as a sun is more brilliant than a planet; but it was no such triumph of human genius.

Now let us come back to this solar system of ours, for we want to see how this great law of gravitation holds all these worlds in place. We have seen that the sun is the great attractive power, having far more influence than all the planets combined. We have also seen that they are scattered around him in their various orbits. Acting thus on them singly, and with so much force, how is it that he does not draw them in? It is specially to be noted that the planets nearest to him, on which he exerts the greatest force, are the small ones that can least resist him. It is quite remarkable that

THE FOUR INNER PLANETS

are small, while the four outer ones are large. How comes it that the inner ones, at any rate, are not drawn into the sun, and consumed?

This catastrophe is averted by the swift movement of these bodies round the sun. If they cannot resist his influence by their own weight, they can resist it by their rapid motion. Swinging around him, as they do so quickly, they have a tendency to break away beyond his control, while he is striving all the time to drag them in. These two forces being equally balanced, the planets keep their distance from the sun, and move steadily in their appointed paths. If the sun's attraction should lessen, they would break away into space; if their speed should lessen, the sun would draw them in. Their safety depends on the balance of these two forces.

You can realize this very clearly by tying a stone to the end of a string, and swinging it round your head. You feel the pull of the stone on the string in your hand; and the faster the stone moves, the greater is the pull. If the movement stops, the stone falls. It naturally falls to the earth because the attraction is in the earth; if the attraction were in your hand the stone would fall to your hand. If the string should suddenly snap, the stone would break away.

Now in the planetary system, instead of a string we have the subtle, unseen force of attraction. Moreover, attraction acts with varying force on objects of varying distances; unlike a string which is rigid, communicating force equally to all objects, whether near or far. Making due allowance for this, the stone and the string give us a graphic picture of the way in which the earth—say—is kept in her place. And if we had a number of stones, large and small, on strings of various length, and moving with varying speed, that would give us some idea of our planetary system.

Are we to suppose, then, that all these planets are of such an exact weight, and placed at such exact distances from the sun, and impressed with

SUCH EXACT VELOCITY

in their orbits, that they exactly keep their place. I believe that this is what astronomers assume; but I confess it seems difficult to accept such a theory. The problem seems to me to involve far too fine mathematical calculation and arrangements.

Just consider what this problem does involve. Let us take the earth as an example. She has kept exactly to her orbit through ages and ages past. How did she manage to accomplish this feat? The theory is, that she was given an exact weight, and placed at an exact distance from the sun, and given an exact velocity; and that by these arrangements she has exactly kept her path. Does this seem credible? What infinite nicety would be involved in these various combined calculations. Does not nature attain her ends, usually, in a far more direct and simple way?

But then, the arrangement is complicated by other circumstances. Account has to be taken, not only of the sun's attraction, but the attraction of all the other bodies in our system. There are ponderous globes like Jupiter or Saturn, as well as many smaller ones, that attract the earth more or less. Now a very slight attraction might move her a little from her path, with the result that she would swerve farther and farther astray. Not only so, but these other attracting bodies are

CONSTANTLY CHANGING

their place, and attracting the earth at every different angle. And so, each one of these forces—an endless series of them—would have to be calculated and provided for, else the intended arrangement would fail. Is it credible that this is the method—or the sole method—by which the earth maintains her position? It is not surely by such endless calculations and complications that nature usually attains her ends. The methods of nature, on the contrary, are usually as simple as they are sublime.

Now if these involved arrangements are needed in the case of the earth, they are equally needed in the case of each one of the planetary worlds. An endless metaphysical problem would thus seem to be involved in keeping these worlds in place, and preserving them from destruction. Is it credible that by such an arrangement the worlds "stand this day as they were ordained?"

Astronomers admit that planets are more or less deflected from their path; but the astounding thing is, that these deflections are rectified. How they are rectified I believe no man can tell. I have read an elaborate account of how they are rectified, but it only left me in a haze. I think it would be as well to say "I don't know." The fact remains, at any rate, that

IN SPITE OF ALL DEFLECTIONS,

the system maintains its equilibrium. An eminent astronomer says that "planetary perturbations are unable to threaten the stability of the solar system." Is there not here a hint of an intelligent, controlling power?

At any rate, it would seem to me that the theory we have been reviewing can never be proved. An eminent authority says that "the problem of three bodies is insoluble." That is, if we have two bodies attracting each other, and both attracted by a third, and both attracting the third, the exact effects are beyond calculation. But in the theory we have referred to there are not three but hundreds of bodies acting on one, and all acting on each other, from ever changing directions. Surely, such a problem is indeed "insoluble." I believe the infinite Mind could solve such a problem; but the analogy of nature does not seem to warrant the idea that the problem is required.

I do not conceive that in expressing an honest doubt of any special doctrine there is any onus laid on me to produce an alternative. If we do nothing more, the discrediting of an error on good grounds clears the way for the truth. If I were to advance an alternative theory as to the arrangement of the planetary worlds, it might be declined on the ground of being unscientific. All the same, I have the idea that the infinite and eternal Creator, who made all worlds, has some way of superintending them—direct or otherwise—by which their movements and positions are controlled. Attraction may be one force which He uses for the execution of His plans; but possibly it is not the only force. It may be the best up to a certain point; beyond that point He may have a better. I conceive of Him as a person, not as a mere force; so He can choose what means He will to attain the ends in view. As I say, this may not seem scientific. We know, however, that every effect must have an adequate cause, and in astronomy especially we meet with wonders which are utterly bewildering if we cannot ascribe them to the great first cause, which is God.

I had not intended to discuss this abstruse question at all, and perhaps I owe you an apology for introducing it; there are sufficient wonders in astronomy if we keep to the regions of certainty. Since this abstruse topic has been introduced, however, I may quote Kepler's

THREE GREAT LAWS

of the planetary motions. They are these:

1. Each planet revolves round the sun in an elliptic path, having the sun as one of its foci.

2. Each planet revolves round the sun with such a velocity at every point that a line drawn from it to the sun passes over equal areas in equal times.

3. The squares of the periodic times are proportional to the cubes of the mean distance.

If these laws are too abstruse for you, let them go. This is not a scientific treatise. I am simply trying to exhibit some of the glories of creation in a way that everybody can understand. And it is a happy thing that these glories are open to all who have eyes to see and hearts to adore. "There is no speech nor language where their voice is not heard."

Since the foregoing was written it has occurred to me that my incidental allusion to the method of making and placing of the worlds in the solar system may not be quite satisfactory to some who would wish to carry the matter a little farther. It may be well, therefore, to go a little more into detail in regard to the nebular theory. This is the theory which, I believe, most astronomers adopt as accounting for the orderly arrangement of the bodies in our solar system. In discussing that theory we may have to repeat some of the points already made; but that will be no disadvantage, if thereby the matter is made clearer.

To be quite fair, it is right to say that there are two different bases on which the theory in question may be accepted. There is a natural and a supernatural basis; and it will be seen that there is a fundamental difference between the two. Let us, first of all then, state in the briefest terms what the nebular theory really is.

The nebular theory supposes that away back in the hoary past, before the worlds were made, there was an immense body of very hot vapor that filled the entire domain of our present solar system, and that this was the world stuff out of which the sun and planets and moons were formed. The theory supposes that this vast body of vapor turned on its axis; that in doing so it cast off puffs of vapor from time to time; that these puffs of vapor began at once to revolve on their axes, and also to revolve round the central mass, and thus after long ages became planets; that the planets while still in a state of vapor threw off smaller masses, which in time became moons; that the central body became the sun; that a cooling process was going on during all these ages, whereby some of the small bodies, such as our moon, became cold, and that others are in various stages of transition, while the sun, being so large, is still intensely hot. I think this is a fair summary of the famous nebular hypothesis. And this is the theory which is held to account for the making and placing of the worlds.

Now it will be seen at once that this theory has several circumstances to recommend it. Supposing there was such a mass of revolving vapor, there would probably be a surging of its mass towards its equator, where its motion would be the most rapid, and from thence there might be projected into space the masses supposed.

Again, the central mass being of such immense volume, we can believe that the masses cast off might be large enough to form the planets.

Further, these masses would naturally assume the form of globes, on the same principle that rain distils into drops.

Naturally, too, I think such masses, thus thrown off by a revolving body, would begin to turn on their axes, and also to revolve around the central body.

Besides; the cast off bodies would certainly revolve in the same direction with the central body ; and this, with two notable exceptions, we find to be the case.

Still more; the earth seems to be undergoing a cooling process, which gives us a hint that such may be the universal law.

These are important circumstances to be taken into account as favoring the theory. I suppose, indeed, it was mainiy on these circumstances that the theory was originally founded.

Now I have said that this theory can be adopted on a natural or a supernatural basis. I mean that taking it on a natural basis it recognizes only the operation of natural laws. According to this view, all the processes of this wonderful evolution of the worlds were effected entirely by inherent natural law, without any action or interference on the part of a directing Intelligence. The theory, taken on a supernatural basis, accepts the entire process, but postulates also a supreme, superintending Mind by which the results were attained.

Now I may be wrong, but I think it is the purely natural theory that is usually held by scientists ; that is, that the operation of natural law evolved this solar system from the primeval mass of world vapor. I want to see if this theory gives a reasonable solution of the phenomena. And in order to get the most concrete view of the situation, let us dismiss from our view all the planets of our own system but the earth herself. Let us also dismiss the idea of her daily motion on her axis. We simply want to see if the theory in question will account for the earth's position, her well defined orbit, and her uniformity of motion round the sun.

Now if we inquire how the earth keeps her place—just so far distant from the sun and no farther—the universal answer will be, that the sun's attraction of the earth is exactly balanced by her tendency to fly off into space, and that thus she is kept securely in her place. That is to say, on the theory supposed, some blind force in the central mass, entirely undirected by any intelligent power, flung out this earth to the exact point in space where these two forces would be mathematically balanced. Only at that exact distance could she be safe. If sent even a little farther she would gradually break away from the sun's attraction, and be ultimately lost in space. If sent out almost but not quite so far, the sun's attraction would be a little too strong, with the result that she would gradually contract her orbit, and ultimately be drawn in. Thus there were uncounted millions of chances for her to get into the wrong place, and only one chance to get into the right place ; but this blind force called law sent her out to the one exact spot where she would be safe. A marvellous phenomenon, surely, to be accomplished by blind force !

But then, think of the other factors that had to co-operate in securing this result. The central mass needed to revolve with a very definite velocity to have the necessary force to hurl out this planet just so far and no farther. Had the revolution of the central mass been slower, the planet had not come far enough; had the revolution been faster, the planet had gone too far. But the propelling force, acting by unintelligent law, was exactly sufficient for the occasion!

Then the planet so projected needed to come from some definite part of the central body. If it were projected from the equator, where the movement was most rapid, it would certainly be sent farther than if it came from the region of either pole. But this matter, on the natural nebular hypothesis, was also arranged with mathematical exactness, so that our planet came just where it ought to come!

Further; the mass of the planet itself had to be arranged. Granted that the motion of the central body would give the necessary impulse; granted also, that the planet came from that part of the central body where the impulse was just sufficient, and no more; still, the planet itself had to be of a certain exact weight in order to get to the one spot in the universe where it would be safe. But, marvellous to say, the planet was weighed to a nicety before being despatched on its career; and this, too, was attended to by blind, mechanical law!

Again; the speed of our planet in her motion round the sun had to be pre-determined with the utmost exactness; for on this, as well as her distance from the sun, her safety depends. If she happened to move too slowly, the sun would surely draw her in. If she went a little too fast, she would overcome the sun's attraction, and dash out into space. But there was no mistake here, where mistake would seem to be so easy. Blind law arranged the matter to a mathematical nicety, and secured an equilibrium between these two opposing forces!

Besides; though the earth actually does move faster in certain parts of her orbit than in others, and though she does draw nearer to the sun at certain times, yet she makes her entire revolution with unerring exactness from year to year. And this marvellous arrangement, which some hold to be an insoluble problem even yet, was all provided for by an inanimate mass of vapor blindly throwing off a puff of its vapor into space!

The last named consideration suggests this also: that the attraction of other bodies besides the sun had to be reckoned with. All the bodies in the solar system attract each other in proportion to their proximity and weight. This fact would surely count for something in arranging for the earth's stability, and her uniformity of movement. Not to speak of many smaller bodies, Venus is our nearest planet, and she is almost as large as the earth. Uranus and Neptune are each fifty or sixty times larger. Then we have Saturn and Jupiter, the one a thousand times, and the other twelve hundred times, larger than the earth. Surely the attraction of these bodies might deflect the earth from her orbit, or influence her rate of motion.

And one supreme difficulty would seem to lie just there. For these bodies are always changing their position, and thus drawing on the earth at different angles, so that their total effect is a very difficult thing to calculate. I quoted before the statement of an eminent astronomer to the effect that the problem of three bodies is insoluble. Then how insoluble must be the problem of many bodies of different sizes, at different distances, attracting the earth at ever-varying angles. Yet, the marvel remains, that the earth keeps her place, and makes her revolutions with unfailing exactness, as though there were no element of disturbance anywhere. We would consider this an astounding adjustment if it proceeded directly from an intelligent mind; but what can we think of it as the result of blind law, implied by the natural nebular theory?

Then it has to be added to all this, that the same wonderful adaptations and arrangements had to be repeated in the case of every other planet; for each one of them, so far as known, has its place and movement determined with the same exactness as our own.

And there is one other circumstance that must not be overlooked. I said before that with two notable exceptions, the bodies supposed to be thrown off revolve in the same direction with the central revolving body. This they would of course naturally do, if thrown off as supposed. But the two notable exceptions interpose a serious difficulty to the main theory. The exceptions are the moons of Uranus and Neptune. Most strange to say, their movement is in the contrary direction. This is a circumstance which can by no means be accounted for on the nebular theory. Some other law would seem to have been at work here, but what that law might be is a mystery profound. This one strange circumstance, if there were nothing else, I think must go a long way to discredit the nebular hypothesis.

In view of such considerations as these, I think I need hardly say that the mystery of the making and placing of the worlds must be explained—if explained at all—by some other method than the nebular, considered as a mere natural process.

Are we shut up, then, to accept the nebular theory on what I have called a supernatural basis? According to this view, the nebular process remains; but it is directly controlled and supplemented by divine power. Natural law goes a certain length; divine wisdom and energy then come in to complete the process, and obtain the intended results.

I confess I have some difficulty in accepting this solution of the mystery. For consider what such a solution involves. It admits that natural law would reasonably account for the throwing off of masses of matter from the central body; but it does not admit that natural law is equal to the making of such masses of an exact weight, and of throwing them out just to the exact place where their tendency outward would exactly balance the sun's attraction inward, and where, moreover, they would have the proper rate of motion to ensure their safety.

It is not conceivable, I think, that natural forces of themselves would effect such marvels. It is very conceivable, however, that divine power might effect them. To me there is a difficulty in conceiving of these two forces so acting in unison. Imagine a natural force throwing out a mass of matter at random. Then imagine divine intelligence coming in and fixing the weight of that mass, fixing its velocity outward, fixing the point where it must stop, and thus fixing its rate of movement round the sun.

I say it is difficult for me to conceive of such a dual operation. It would be almost, if not quite as easy for me to fall back on the most primitive theory that the worlds were simply made and placed where they are by direct creative power, without any reference to nebulæ whatever. This may be considered very primitive. I do not commit myself to it, but when to the difficulty I have named is added the contrary movement of the satellites of Uranus and Neptune, I think the nebular theory must await further demonstration.

One thing we may be very well assured of, and that is, that creative Intelligence and Energy must come in somewhere. That is the main conception after all. We have to beware lest in our zeal to explain everything on a scientific basis, we fall into the error of the fool who says in his heart that there is no God. That there is a God nature everywhere proclaims; but whether His creative and ordaining power wrought in accordance with the nebular theory or in some other way, is of no great importance to us now. I hold it to be more scientific, as well as more reverent, to keep an open mind. We may well put this mystery along with a good many others which perhaps may not be solved on this side of time.

CHAPTER IX.

ERRATIC WANDERERS OF THE SKY.

Comets—Appearance—Erratic movements—Extreme elliptic orbits—Gaseous—Harmless—Immense periods—Halley's great prediction—Near approach to sun—Why not absorbed—Do comets belong to solar system?

WE have spoken of the sun and his family of planets as being bound together by the bond of attraction. We also casually referred to the comets as

THE PRODIGALS

of the family. They are erratic wanderers; or so they seem; if all were known, perhaps they are controlled by laws no less constant and sure than those that control the planets. Not very much, however, is known about them. But they are so picturesque, sudden, and uncertain, that we note here a few leading facts.

The appearance of a comet used to cause terrible alarm, as well it might, until it was discovered to be harmless. Being composed of a light gaseous substance, it is now believed that if one of these bodies should collide with the earth it would do us no serious injury, except for the noxious gases it may possibly contain.

The London *Morning Leader*, in referring to Comet B. 1902, says:

> "Time was when the appearance of a comet in the sky threw the ignorant and the superstitious into convulsions of terror. Prof. Falb, the most famous and most unreliable of modern prophets, was probably trading on this popular feeling when three years ago he announced that the comet then approaching the earth would collide with it at two o'clock in the morning of November 13th. A number of timid people prepared for the end of the world, and a great many more sat up on the night of the 12th out of curiosity just to see what would happen."

Comets are of various forms, but their general characteristic is that each of them has a head and a tail. Sometimes they have several tails, spread out like a fan; such was the comet of 1744. The head, or nucleus, is more solid than the tail, and for the most part shines by its own light. The tail reflects the light of the sun. Of the very brilliant comet of 1858 it was reckoned that four-fifths of its light were its own, one-fifth only being reflected by the sun.

There is no accurate historic record of the appearance of comets until the last few centuries; but from casual hints we learn that they have appeared in all ages, one dating back as far as 52 B.C. The most brilliant ones that appeared during the past century were those of 1811, 1843, and 1858.

The motions of comets are exceedingly unlike those of planets. It is claimed that Newton demonstrated them to be governed by the same laws; but, if so, the laws have a very diverse operation. For one thing,

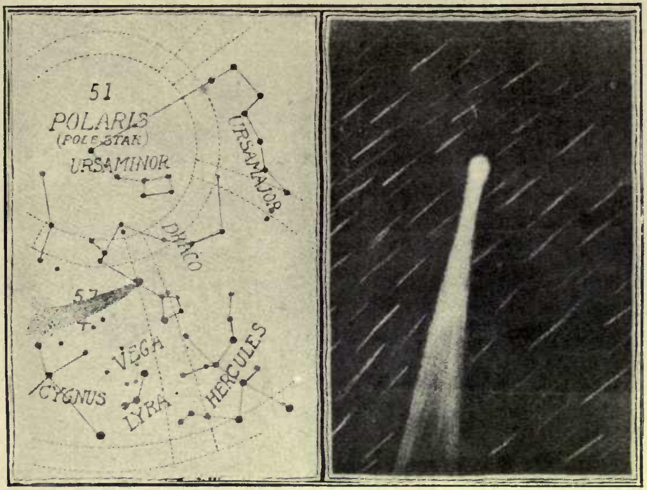
THE ORBITS OF THE COMETS

are very far from being circular. They are very extreme ellipses instead ; that is, so far as they have been traced. The orbits of those that have been accurately calculated and traced are comparatively few. The chief of these are the comets of Encke, Biela, and Fage. Even of those that are supposed to be calculated there may be reasonable doubts ; for as the bodies are gaseous, they may be much changed in form throughout their immense revolutions. Hence, it is not easy to identify a comet if it does return ; and so, a comet which we think we have identified, may be a different one altogether.

Along with the gaseous composition of the comet, so liable to be changed in form, consider the

IMMENSITY OF SPACE

through which it moves, and the unknown forces it may meet with on its way, by which its appearance may be quite transformed. The comet of 1811 was supposed to go out into space fourteen times farther than Neptune, the outermost planet of our system. Such a sweep into space is bewildering, yet that seems to be far exceeded. The comet of 1844 was estimated to go out into space four thousand times farther than Neptune ; and its time of revolution was reckoned to be 100,000 years. The comet of 1680 was calculated to have a period of 8,813 years. I doubt if there are sufficient data for these calculations ; but certainly the sweep of these erratic bodies must be vast. If the comets do go out so far



THE GREAT BORELLI COMET OF 1903.

A writer in the New York *Sun* had the following verses on the celestial visitor :

O wayward world, thou fleeting, wandering star,
Now rising in the firmament afar ;
With bulk of earth a myriad times combined,
Stupendous tails, four million miles behind ;
Whence comest thou ? And whither dost thou go ?
What dost portend to mortals here below ?
Dost thou bear evil tidings to mankind ?
With ruin will thy path be strewn behind ?
The universe in terror looks upon
Thee in thy race, so madly rushing on.
Throughout the realms of vast and endless space,
Canst thou not find thine own appointed place ?
Or art thou some lost world being now destroyed,
That once, like planets fixed, full rest enjoyed ?
May one full potent and majestic sun
Hold thee in check, nor let thee reckless run,
With no fixed friendly planet interfere,
And send thee safely from our system here.
The moon and all the stars suffice as lamps ;
A need have we for no celestial tramps.
May no obstruction hinder in thy flight—
Good night ! thou wayward, wandering world, good night !

into the dim, unknown spaces, we can have no idea of the modifying influences they may meet with from other bodies, and thus their supposed identification may be an illusion, and their supposed periods equally an illusion. We cannot afford to be dogmatic in a field of so much mystery.

In what I have advanced here I have no idea of discounting Halley's great prediction of the return of the comet that bears his name. This comet appeared in 1682, and

HALLEY IDENTIFIED IT

as one that had appeared twice before. With such data as he possessed, he calculated its period, and predicted its return. In doing this he went into a careful estimate of the delay the comet might meet with, owing to the attraction of some of the larger planets. He allowed so many days here, and so many days there, and fixed the return for 1757 or 1758. He did not live to see if his prediction would be fulfilled, but it was fulfilled; the comet retured in 1758.

A comet appeared so late as the year 1903. We may call it the Borelli comet, because it was discovered by Borelli, at Marseilles. It had no special interest for us, because it appeared to the naked eye only as a star; at least it required a keen eye to discern its tail.

The telescope, however, showed that it had two tails, which is quite an unusual circumstance.

This latest comet was computed to approach within 31,000,000 of miles of the sun. This may be considered a near approach, being about one-third of the earth's distance from the sun. But the comet was not absorbed by the sun, as our earth certainly would be if she ventured so near. In due time the comet began to recede, and steadily pursued its way into unknown space. Professor Perrine claimed to compute its orbit. It is doubtful, however, if any such computation can be relied upon, and if the comet ever returns, it is doubtful if it can be identified.

The mystery about comets in general is that we know not where they come from, nor where they go; and they probably change their form so much by the attraction of other bodies that if they did return we should not know them.

Now after what I have said as to the difficulty of identifying a comet on its return from space, I am bound to believe that Halley may possibly have made a mistake. At the same time, it is far more pleasant to think he made no mistake; and I strongly incline to that view. And so this prediction is considered one of the most notable achievements in astronomical science. It takes rank with the discovery of the planet Neptune, and the sun companion of Sirius.

We have said that the comets are very peculiar in the extreme ellipses of their orbits, and the immensity of their revolutions. They are still more peculiar in that they have no uniform direction, as the planets have. The planets in every case move from west to east, but the comets as often move from east to west. In fact, they seem to be

AMENABLE TO NO PLANETARY LAW

whatever. A striking instance of this is seen in the way a comet will approach the sun. It will rush towards him with such tremendous speed that it would seem certain to be absorbed. But it is not absorbed. It rushes round him at very close quarters, and breaks away again into space. Had a planet taken the same risk, it would have certainly been absorbed; but this light, gaseous body escapes. How does it resist the sun's attraction? Why is it not absorbed? How does it get away? We simply do not know.

We have said that the comets usually move with great speed. That of 1680 was calculated by Newton to move at the rate of 880,000 miles an hour. It rushed towards the sun at that pace, rushed round him, and then rushed away into space with but slightly diminished speed. What force is it that draws it away into space in spite of the sun's attraction? Again, we do not know.

Though by no means an authority on the question, I cannot but have my doubts as to whether the comets belong to the solar system. Astronomers generally hold that they do; but I believe there are some who dissent from this view. I may briefly state some of my own reasons for supposing that the comets are no part of our system at all.

First, there is the fact that the sun is not the centre of their orbits. They do not obey his laws. They are largely independent of his attraction. They come almost close to him, and then dash away into regions unknown. If ever they come back, it is not in obedience to the sun's attraction. Even if a comet completed its whole revolution

WITHIN THE ORBIT OF NEPTUNE,

I would not consider that it belongs to the system, inasmuch as the sun is not the centre of its orbit. It really seems to be controlled by unknown forces quite outside the solar system.

In the next place, the comets have no uniformity of movement. If they have been thrown off by the sun, according to the nebular theory, they must of necessity move in the same direction as all the other bodies that have been so thrown off. But they acknowledge no such law. Some of them move from east to west, and some from west to east. This seems a difficult circumstance to account for on the supposition that they are part of our system.

Again, so far as we know, these bodies move in extreme ellipses. We do not see how, on the nebular theory, they could have received such a direction. A circle, or nearly a circle, such as the planets have, seems the inevitable direction. Does it not seem more likely that a comet might be influenced by two different forces somewhere outside the solar system? These forces might be attractive, drawing the comet back and forth in its elliptic orbit. Or the supposed forces might be repulsive, throwing the comet to and fro like a shuttlecock. I believe we are too much disposed to the idea that the universe consists of endless systems of globes revolving round greater globes. A larger view of creation might show us that it has other features very diverse from this.

Then, further; the limits of the solar system seem far too contracted to furnish orbits for some of the comets. This must be so, if the estimate which we referred to lately, comes anywhere near the truth. The estimate was that the comet of 1844 goes out into space

FOUR THOUSAND TIMES FARTHER

than Neptune. Now taking this bold estimate as true, consider what it means. We said a while ago that light—the swiftest thing we know—would actually go round the world seven times in a second. How distant then the sun must be ; for light would require eight minutes to reach him. But light would not reach Neptune in less than four hours. Now the comet under review goes out into space four thousand times farther than Neptune. How long would light require to reach the comet ? No less than six hundred and seventy years. Thus the comet would go far beyond the range of the sun's attraction. Yet it turns and comes back. Why does it come back ? What power causes it to change its course ? Certainly not the sun, nor any attractive power within the solar system. If the sun could not hold it when it was almost within his grasp, how can he manage to bring it back from the dim immensities of space ?

And then, not only does this comet go far beyond the sun's influence, but it gets well within the influence of other suns. Then of course

IT NEVER COULD RETURN,

except there are other forces to accomplish this, of which we know nothing. It would seem, therefore, that if the estimate of that comet's orbit is anywhere near correct, the comet cannot belong to our system.

I am thus led to say, lastly, that for ought we know, some of the comets never return. I know that this is not the usual opinion. Because a few of them do return, it is generally assumed that this law governs them all. But we must beware of a too hasty generalization. In our quest for certainty we must learn to be patient until things are proved.

Now we know so little of the comets as a whole that it seems better to await further discovery, before adopting any general, comprehensive theory. The uniformity of nature sometimes disposes us to premature conclusions. But we have to remember that in nature there is great variety as well as great uniformity. And the very small portion of universal nature that is actually open to our survey, may well make us pause. So far as actual observation has gone, it would seem to be not improbable that certain comets might move in varying curves, or even straight lines, as well as in narrow ellipses. This will account for our limited knowledge of these erratic wanderers. And the universe is wide enough for the most stupendous movements. The more we know of the glories of creation the more sensible we are of the vastness of the unknown. The larger the circle of light, the larger must appear the enclosing circle of darkness.

CHAPTER X.

CELESTIAL FIREWORKS.

Shooting stars—Their origin—Appear singly or in shoals—A large one that fell in America—Magnificent display in 1866—The thirty-three year period—A notable prediction fulfilled—Destiny of these baby stars.

We have seen that some of the heavenly bodies are of immense size. Many of them are worlds far larger than our own. But now let us turn for a moment from the immense to the minute. There are very small bits of matter floating through space, which we see sometimes igniting in the air, and falling to the earth. These are what we call shooting stars.

Astronomers make a distinction between shooting stars and meteorolites; but that distinction we need not mind just now. We shall

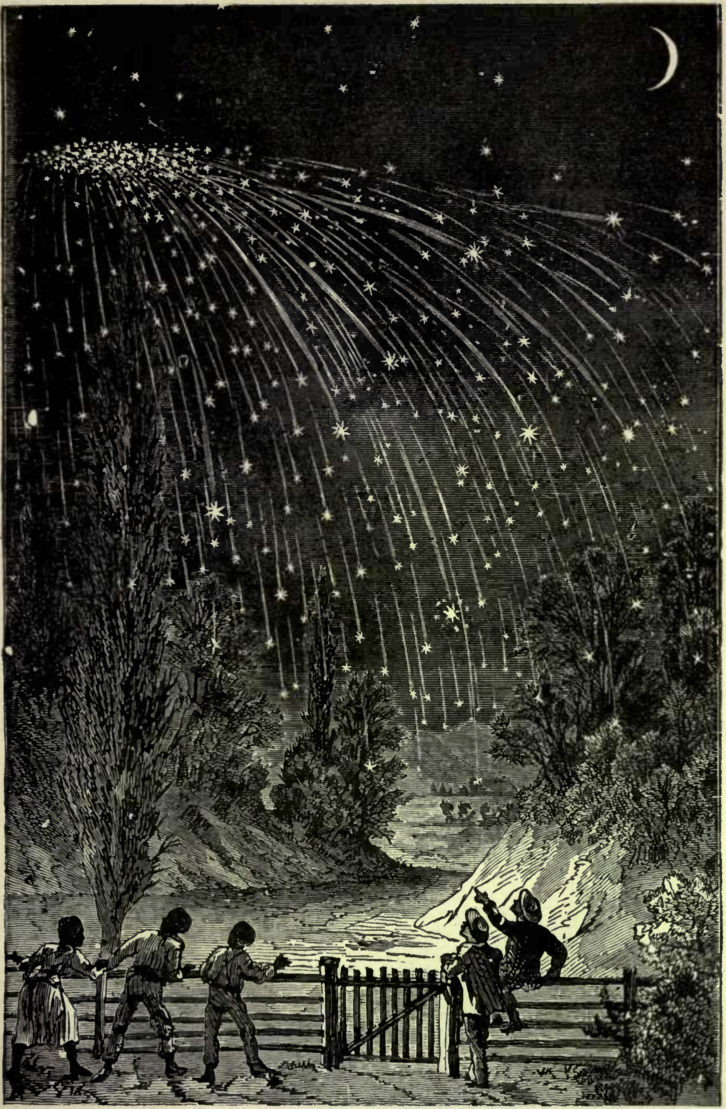
GLANCE AT THESE METEORS

as one class, and simply call them shooting stars. It would be interesting to know where these stars come from, how it is that they are brilliant, and why they fall and disappear.

Where they come from originally we are not certain. Some think they are thrown up by volcanoes, while others suppose they are bits of matter broken off from larger bodies in space, and that they find their way to the region near the earth, and are carried round the earth. Their brilliancy is caused by the friction of the atmosphere. Moving as they do with great speed, when they strike the atmosphere they take fire and become bright. If they are very small, they soon burn themselves out. Hence when you see a falling star, it usually disappears before it reaches the earth. That is because the star is burnt out; nothing remains of it but vapor which is dissipated in the air.

But sometimes, when the star is of a larger size, it does not burn itself out, but falls to the earth as a solid body. We have some remarkable accounts of bodies of considerable size falling to the earth in this way. Perhaps the most notable case on record is that of a meteor that fell in America in the year 1876. First it appeared in Kansas; then it moved over Illinois; at length it was lost near Niagara. It was estimated to move at the rate of fifteen miles a second. When near Chicago it exploded in balls of fire, and the report was heard 180 miles away. This may be taken as a very large sample of a shooting star.

There are certain periods when we have shoals of these stars. It appears that about once in thirty-three years the earth encounters myriads of them in her movement round the sun. The theory is, that these stars are themselves moving round the sun, and that they make the revolution once in about thirty-three years. Hence the earth encounters them, more or less directly, once a year; but



A SHOWER OF METEORS.

ABOUT EVERY THIRTY-THIRD YEAR

she passes right through them. From an experience of this kind in 1799 it was predicted there would be another in 1833, and one again in 1866. These predictions were fulfilled. You will notice that there are periods of about thirty-three years between these different showers of stars.

In 1866 we passed through a veritable celestial rain of meteors. It was the most brilliant display of the kind, perhaps, ever witnessed by man. At a late hour, on a certain night in November, the stars began to appear. First they came in ones and twos; then

THE NUMBER GRADUALLY INCREASED

until they came in shoals. It was calculated that they appeared at the rate of fifty-seven a minute, and the total number was estimated at two hundred and forty thousand.

What the fate of these baby stars may be, we cannot say. Some of them may fall to the earth; some of them may be consumed in our atmosphere; others may find their way out into space, and attach themselves to some other sphere.

CHAPTER XI.

MAKING AND PLACING OF THE WORLDS.

Nebular theory—Process of making worlds—Creation not excluded — Arguments for nebular theory — Arguments against it—An open mind.

AT different stages we made a passing reference to what is called the Nebular hypothesis. This is the theory that accounts for the sun and planets being placed just where they are, and for the performing of their several duties with so much exactness. It is certainly a bold adventure to launch a theory to account for the making and placing of these worlds. And yet it is a reasonable thing to do, if only it can be done in a reasonable way. For there is a unity in nature whereby many effects flow from one cause. There is also an instinct of unity in man whereby he inclines to trace things back to first principles. It would be a gratifying thing, therefore, if some

ONE ORIGINATING CAUSE

can be found whereby the sun and the planetary worlds were arranged in their present order and beauty.

I may say here that this nebular theory, if I rightly understand it, does not exclude the theory of creation. You may believe that the worlds came by chance; or you may believe that they were placed here by an intelligent, personal Creator; yet, holding either view, you can accept the nebular theory. I say this, that you may not be prejudiced either way until the matter is examined.

Let me try, then, to present this theory in a few words. It is supposed that the vast space now occupied by the solar system, from the sun outward as far as Neptune, was once filled with very hot vapor. It is believed that this mass was turning round on its axis. It is believed that the mass was in

A PROCESS OF COOLING;

a very slow process, of course, both because of its immense bulk and intense heat. As it cooled the vapor would naturally condense, and thus the whole mass would be in a process of contraction. Thus contracting, and still moving on its axis, masses of vapor were thrown off from time to time. These masses took a gobular form, were of various size, and were thrown to various distances. The revolution of the central mass gave these thrown off fragments a movement round the contral body, and also a movement in the same direction on their own axis. Then through ages and ages the cooling process went on. The central mass contracted more and more, and became the sun. But being so large, he has not yet cooled beyond the stage of vapor, and very hot vapor too. The fragments thrown off, being smaller, would cool more quickly. These are the planets, at present in varying stages of cooling, in proportion mainly to their size. Thus some of the larger ones are partly vaporous yet; others show signs of being partly liquid and partly vapor; others, like our earth, have got so far as to have a solid crust on their surface,

WITH LIQUID FIRE BELOW;

and still others, very small, have reached the condition of solids. I ought to have said, too, that these planets, while in the vapor stage, threw off smaller bodies, just as the sun had done; and these smaller bodies became moons, revolving round the planets from which they were cast off.

I think this may be taken as a fair statement of this celebrated hypothesis. I belive it first occurred to Laplace, and was later endorsed by Sir W. Herschel. These two great names were sufficient, of course, to bring the theory into general favor. With the advent of Lord Rosse's telescope, however, the theory was in some degree discredited; but the conclusions established by the spectroscope in later times have once more brought it into favor. I think it may be said that astronomers in general accept it. But they are certainly not unanimous. I have just been reading the opinion of one eminent authority who claims that the theory would not account for more than one-tenth of the solar system.

We may thus feel at liberty to look at the theory for ourselves. You will observe that nothing whatever is proved. There is no demonstration. The process we have detailed has simply been accepted because it seems the most probable explanation of the method by which the worlds were made and placed where they are.

I must say I feel a little nebulous myself about the whole matter. If anything I say on the question seems to bring you into the same condition, better let the matter go; it is not of supreme importance in any case. Let me note, however, in the first place, a few things by which the theory seems to be sustained.

First, it is no discredit to the theory that it does not account for the original mass of vapor. The theory had to begin somewhere, and it begins with the mass of vapor ready made, instead of going farther back. It does not say how the vapor came to be here, or how it came to be hot, or how it came to revolve. Therefore,

THE IDEA OF CREATION

is not ignored. For all the theory assumes, creation may have occurred at an earlier stage. Thus the hypothesis can be accepted by believers or non-believers in creation.

Given, then, this mass of whirling vapor, it seems natural enough that parts of it might become detached. In the neighborhood of the equator, where the motion would be the quickest, the centrifugal force might overcome the centripetal, and fragments might be thrown off. These fragments, too, would most likely vary in size, and be thrown out to various distances.

It seems inevitable, too, that the central mass, in throwing off such fragments, would not lose its globular form. On the same principle,

THE FRAGMENTS THROWN OFF

would take the form of globes. The universal law that distils the rain into drops would form these plastic masses into globes.

Then, it is exceedingly likely that any body throwing off such fragments, and still swiftly revolving on its axis, might become slightly flattened at the poles, and slightly bulging at the equator. This would arise from the centrifugal movement of the plastic mass towards the equator; and this would result in flattening more or less at the poles. Some of the globes are really of this form, notably our own earth.

Further, there is a presumption that the cooling process is still going on. There is no actual proof of this, but it is generally assumed; and, so far as the presumption is true, it is favorable to the theory.

I think these are the main circumstances that would be adduced to support the hypothesis. As I have said, there is no proof. It is a case that does not admit of demonstration. A high degree of probability would warrant our acceptance of the theory; the question is, whether there is a reasonably high degree of probability. Let me, therefore, notice a few things that seem to be opposed to the theory, and that ought to be recognized.

It is worthy of notice that the flattening of the poles is by no means a uniform law. The sun himself appears not to be flattened at all. Professor Ball says this is owing to the sun's slow movement on his axis. But the sun's movement at the equator is

NEARLY TWENTY TIMES AS QUICK

as that of the earth. We would expect, therefore, that the sun would be more flattened at the poles, proportionately, than the earth ; but the very contrary is the case.

Then there is the great difficulty of getting the planets into place, agreeably with this theory. If this operation of throwing off the planets be taken to have wrought simply at random, apart from any intelligent control, it is utterly inconceivable that the planets would have been thrown so exactly into their orbits where we find them. Consider for a moment how incredible a thing this must be. You have here a huge revolving mass, casting off a fragment now and then into space, as a boiling pot might cast off a jet of steam. Then consider the order and beauty to be evolved by these random operations. The masses thrown off have to find their orbits from which they will not deviate through all time. To accomplish this

MARVEL OF ARRANGEMENT,

the earth, say, must be of a certain weight, must be projected to a certain distance, and impressed with a certain velocity, else she cannot keep to her orbit. Yet these remarkable and unheard off results are achieved by a mass of matter throwing off a fragment at random into space. And what was necessary in the case of the earth was necessary in the case of every planet, whether large or small, that revolves round the sun. Surely such a theory is beyond belief. Yet that is the position they must take who believe that the nebular operation was simply the effect of a natural law, without any intelligent controlling power in the disposal of these worlds.

On the other hand, if you say that this was the operation of a natural law, and try to mix up with that an intelligent controlling power, you have still a serious difficulty. If it is not conceivable that the natural law, working of itself, could accomplish such marvellous results, it is conceivable that an almighty, personal Creator, could accomplish them ; but to mix up the two ideas is to involve ourselves in difficulty and confusion. I would find it easier to take one theory or the other singly, rather than unite them. To me the most simple and reasonable course seems to be a clear recognition that "the worlds were framed by the Word of God," without being too definite as to the method by which this was accomplished.

One special difficulty in the way of the nebular theory is to account for the

MOVEMENTS OF THE SATELLITES

of Uranus and Neptune. If the theory is true, surely the movement received by all the planets and satellites must be in one direction. But here we encounter the striking exception of the satellites of these two planets. Every other body in the entire system moves from west to east; these satellites, on the contrary, move from east to west. How is

THIS RETROGRADE MOVEMENT

to be accounted for? How can it be explained in accordance with the nebular theory? The difficulty seems insuperable.

I might add, that many of the comets have the same retrograde movement as the satellites just referred to. This objection, of course, has no weight if you accept my plea, made awhile ago, that the comets are no part of the solar system. If you adhere to the view that the comets are a part of our system, then you must put a lot of them in the same category with the erratic moons of Uranus and Neptune, and thus your difficulty will be increased.

I am very far from being dogmatic on a question of so much mystery. With such information as I have, I do not accept this theory; neither do I reject it. On this and many other unsettled questions I have no difficulty in keeping an open mind.

As to the method that has been followed in making and placing the worlds, I regard that as of no supreme importance. What I do know is the far more sublime and vital truth that the worlds were made and placed where they are by an intelligent, personal Creator. "He appointed the moon for seasons, and the sun knoweth his going down."

NOTE.—After writing Chapter XI. I deemed it wise to discuss the nebular theory a little more in detail, and this added matter was incorporated in Chapter VIII. Hence, there is some repetition, but as Chapter XI. gives some new points, I let both chapters stand.

CHAPTER XII.

OTHER INHABITED WORLDS.

Joy of discovery—Are the worlds inhabited?—Nature of evidence available—Adaptations—Uses of other worlds—Not light bearers—Day and night—Seasons—Atmosphere—Temperature—Size—Magnificent appointments—Saturn—The minute in creation—Insects—Animalcules—Worlds in drops of water—Argument for habitation—Objections.

If some explorer, sailing through the southern ocean, should discover a new continent, what a delightful surprise and sensation that would be to the whole civilized world. But the question of supreme interest that would at once arise, would surely be: Is that continent inhabited? We should have no rest until we had solved that interesting question. And if we found the new continent to have inhabitants something like ourselves, with customs, arts, sciences, and literature something akin to our own, what an interest would be awakened in that new quarter of the world.

Well, we have only to widen our view a little, and a similar interest will be aroused in regard to the planetary worlds. These worlds are not now so very far away. The telescope has brought them near. We might say that some of them are

ALMOST AS NEAR TO US NOW

as a continent in the southern seas would have been in the early days of navigation. It is true we cannot visit any of these worlds, but there are other ways in which we may have an intelligent idea as to whether they are solitary wastes, or whether they may be scenes of life and activity like our own.

As we look, for instance, at Venus, that beautiful evening star, we cannot but wonder whether there are intelligent beings in that bright sphere. If there are, they may, perhaps, be looking at the earth—a world about as large as their own—and speculating as to whether anybody lives here. But while such a question is very interesting, I presume that in the case of most of us

IT IS SOON DISMISSED

as quite beyond solution. We have met with no visitor from another world, and, as Chalmers says, "We have not heard of the hum of its mighty population."

Yet we believe many things most firmly on which we have no more direct evidence than we have on this. As a rule, absolute certainty is not attainable, and is not necessary. "Probability," as Bishop Butler says, "is the very guide of life." We take action every day in regard to important matters on which we can have no certainty beforehand. And in this we act wisely. Probability is a sufficient basis on which both to believe and to act.

There are different kinds of evidence that convince us that certain things are so. We believe, for instance, there is such a country as Japan, and that people are living there. But, perhaps, we never saw Japan. Even if we know some person who says he has lived there, that would not be absolute proof of the fact. No; but we have seen so many who say they were there, and we know of so many concurring circumstances, that we are assured that there is such a country, and we take action on that conviction.

In the case of a distant city, if you saw the lights in its streets, and heard the hum of its machinery, you would need no further evidence that people are living there. You have no absolute proof of the fact, but you have indirect evidence by which you are fully convinced. Or, if a certain house had curtains on the windows, and furniture in the rooms, and

SMOKE RISING FROM THE CHIMNEY,

you would conclude that somebody lived there. A number of concurring circumstances of this kind lead us to form conclusions that are certain enough for all practical purposes.

Now this is the only kind of evidence we can have in reference to the habitation of other worlds. Perhaps we may find enough of such evidence to warrant us to draw an intelligent conclusion. My own opinion is, that we have sufficient evidence of this kind to give us at least a strong presumption that there are intelligent beings in other worlds as well as ours. I shall, therefore, present some considerations in support of this view.

And let me say here that our argument will apply to the planets only. Hitherto we have been recognizing eight planets, with their moons. There are hundreds more of very small ones of which we took no note. We confine our attention to the eight large ones. The earth is one of these. We want to know what reason there is for believing that any of the others are inhabited, as well as our own.

I would also make this further limitation, that I do not insist that each one of these worlds is inhabited at the present moment. I accept only the general principle that, like the earth, they were "made to be inhabited." Some of them may perhaps not yet be ready for habitation, or they may be in a state of transition from one period of habitation to another.

You will please notice, then, in the first place, that all nature is full of wise, wonderful adaptations. You cannot turn your eyes anywhere but you will be struck with this. See the human body, for instance; notice how every part of it is formed for certain uses. No part of it is made in vain. Look everywhere around you, and you will see the same thing. The rain is made to fall and fertilize the earth; the earth brings forth the things needed to sustain life; we have the day for labor, and the night for rest. I care not where you look, you will find these wonderful adaptations. This clearly indicates that there must have been marvellous wisdom somewhere in arranging things as they are. In fact, all discoveries in science are just discoveries of such adaptations.

We would ask then: What were these planets made for? What adaptations do we find there? Well, we know what our own planet is adapted for. It is adapted for habitation, and serves that end. What, then, where the other planets made for? Were they not made for habitation too? We shall see later on in how may ways

THEY RESEMBLE THE EARTH,

and how they are adapted to habitation just in the same way. Meantime, can you think of any other worthy purpose for which these other planets are specially adapted? We cannot think of any other worthy purpose, but if you find them suited for purposes of habitation, that is one argument for believing them to be inhabited.

But, perhaps, you will say that they give light to the earth, and that this is what they were made for. But the fact is that they give very little light to the earth. Not more than four or five of them can be so much as seen from the earth, except through a telescope. Most of them are immensely larger than the earth, but they are placed so far away from us that

THEY APPEAR ONLY AS STARS,

and give us but a faint glimmering of light. Besides that, they are dark bodies, and can shine only when the sun illuminates them. They are simply reflectors. Now if the principal of adaptation that rules here, also rules in those other worlds, do you think they were intended only to give us light? If that was the object in view, how much better it would have been served by making these planets hundreds of times smaller, and placing them nearer. Think of a man lighting his house by making seven large bonfires, each of them larger than the house itself, and placing them on seven distant hills; yet putting no lights within the house itself. You would say the man was mad. Yet that is the very thing that has been done in making and placing these seven great worlds that surround us, if they serve no better purpose than lighting up this small world of ours. You see there is no proportion; there is

NO WISE ADAPTATION;

there is no correspondence between means and ends. But you see a beautiful adaptation at once when the idea dawns on you that those worlds were made for habitation. And I say that this striking adaptation is an argument that such is the purpose which they serve.

In the next place, let us go a little into detail, and see in how many respects those worlds are adapted for habitation, similarly with our own.

One thing to notice is, that all these worlds are dark bodies, like the earth. Looking at Venus you might think

THE BRIGHT GLARE OF THAT WORLD

might make it an uncomfortable place to live in. But Venus is a dark body like the earth. She shines on us by the sun's reflected light. Our globe shines on Venus just in the same way, and mayhap somebody in Venus imagines that this earth is too bright to be a comfortable home.

Then, further, those worlds are lighted by the sun, like our own. Some of them are nearer to the sun, and some of them farther remote, than we are; but that makes no practical difference. The sun flashes his light into space so far that all the planets surrounding him are illuminated. What would be the use of kindling such a vast fire as the sun to illuminate those distant worlds, if they are not inhabited?

What is more, those worlds have day and night, as we have. They all turn on their axes, like the earth. The side of every globe that is turned to the sun has day, and the side turned from him has night. The day in some cases is longer than ours; in other cases it is shorter; but all these worlds have day and night. In the day they have the sun; in the night they have the stars. Yes, no matter how far away they may be, each one of them has a starry firmament. They do not all see the same stars that appear to us; but the stars sweep out so far through infinity that every planet is surrounded by them.

Now as those worlds have day and night, does it not strike you as very likely that they are inhabited? What are the uses of day and night in this world? The day is meant for labor, and the night for repose. As it is here, so may it not likely be elsewhere? And would you think it probable that there is

A GOLDEN DAWN OF MORNING,

and a gorgeous evening sky, where there is no living being to appreciate and admire? This would surely look like a waste of power, and a useless prodigality of display, such as we do not find in other realms of nature which we are able to explore.

Then there are indications of an atmosphere in the other planets of our system. What is the use of an atmosphere to us? The main uses of it are, that it protects us from the fierce rays of the sun, that it gives us the means of respiration, that it nourishes plant and animal life, and that it is a conductor of sound. There was evidently a great deal of forethought and arrangement in providing us with an atmosphere. Without it we should die, and

ALL THE BEAUTY OF OUR WORLD

would disappear. Now would you think it likely that such a vital thing would be supplied to other worlds where it is not needed? Would you not rather infer that where there is an atmosphere there are also living beings sustained by it? We ourselves do not take the trouble to ventilate malarial deserts; but if we are wise, we try to send the pure air into cities with teeming populations.

So far as we know, too, there are varying seasons in those other planets, as in our own. We noticed before the simple but wonderful way in which the earth is poised in her orbit so as to produce a variety of seasons. More or less the same arrangement is followed in the case of the other planets. This gives them

A SUCCESSION OF SEASONS,

corresponding in some degree with our own. But what is the use of seasons if there is no one to appreciate and enjoy them? Are we to suppose that in those other worlds there is a vernal beauty of spring, a golden glow of summer, and a fading bloom of autumn, but all unperceived and unappreciated? This, again, would indicate a wantonness of display such as we do not find in other realms of nature.

Further, let it be noticed that among these planetary worlds the earth holds no important place in point of size. If the earth were a very large globe, and the others very small, there would be more reason to suppose that the earth only is inhabited. But the case is widely different from this. Of the eight globes we have under review, four are comparatively small, and four very large. Now the earth is one of the small group. She is the largest of the four, however,

VENUS BEING JUST A LITTLE SMALLER,

and the other two much more so. But compared with the other planets, the earth is very small indeed. One of those larger bodies is fifty times of greater bulk than the earth; another is sixty times; another is a thousand times; another is twelve hundred times. It will thus be seen that in point of size our world occupies a very inferior place.

I have made a little calculation which may show the relative sizes of these bodies more clearly than the mere statement of the figures. We shall reduce the earth, therefore, from being a globe 8,000 miles in diameter, to be a globe of one yard only in diameter; and we shall reduce the other planets in the same proportion. Venus, then, would be nearly a yard in diameter; Mars would be half a yard; Mercury would be nearly half a yard. These are the smaller planets. But now look at the larger ones. The earth being one yard in diameter, Neptune would be nearly four yards; Uranus would be over four yards; Saturn would be ten yards; and Jupiter would be eleven yards. Such is the smallness of the earth compared with those other immense globes. And do you

STILL CLING TO THE IDEA

that while the earth teems with intelligent beings, those far mightier globes are untenanted and desolate? Surely an inhabitant of Saturn or Jupiter, if such there be, would have far more reason to doubt the habitation of the earth. But just as likely our small world has never been even seen from Saturn or Jupiter at all.

If the men of Jupiter know how to make telescopes, perhaps some day they will make a very large one, and some eminent astronomer in that world will discover the earth. And we can imagine how such a genius will be lauded for his great discovery. But should some one there suggest that

THE LITTLE SPECK OF LIGHT

just discovered is a world of habitation, he would likely be hooted at as a fanatic; or if they have the nice phraseology in that world that we have here, he would probably be called a crank. Others of a loftier style in Jupiter might say that the question of the earth being inhabited, is "purely academic." To think that the mere existence of us—the lords of creation—should be treated as a question purely academic! It is too humiliating.

Another consideration is, that our earth has no important position among the planets. If we are small, yet if we had some important or central position, that might redeem us from obscurity. We can imagine that a person living on the planet nearest to the sun might imagine that his world alone is inhabited. But the earth is not in that position, being

THE THIRD DISTANT

from the sun. Or if the earth, though small, had the distinction of being the central body around which the others revolve, we might have some show of reason in supposing this to be the only place of habitation. But, as a matter of fact, the earth has no such importance. She simply takes her place with the rest, and moves round the sun in her allotted time, like the others. This does not look as if the earth would be the only planetary orb worthy the dignity of habitation.

Still, further; the earth cannot be considered as an important world in the matter of her appointments and surroundings. In no respect, perhaps, does she appear to so little advantage as in this. Look at her in regard to her moon accommodation. Of the eight planets, there are two that have no moons, so far as we know; but these two planets are the

NEAREST TO THE SUN,

and perhaps may not need moons so much as others. Mars, a smaller body than the earth, has two moons, Neptune has two or more, Jupiter has five, Uranus has eight, Saturn also has eight. Now, the presence of even one moon moving round a planet, gives the suggestion that such a planet is inhabited; for what would be the use of a moon otherwise? But think of a world having five moons; think of another having eight. Do you think such worlds are likely to be barren wastes? In a universe where we see

SUCH A WONDERFUL HARMONY

between means and ends, is it likely that eight moons are shedding their glories uselessly on a lifeless world? And some of these moons are larger than our earth itself. Our own earth and moon moulded into one globe would hardly make one moon for Jupiter. And yet this small, dim world of ours, with its small, pale moon, is inhabited. Can you believe, then, that those larger and more glorious worlds are desolate and dreary wastes? Surely this would be no deduction of reason, but a wanton bound of imagination.

And this last consideration becomes much stronger if we compare our world with Saturn in particular. For there is a special feature of Saturn, besides his eight moons, that gives him a supreme place among these planetary worlds. In magnificence and glory he stands alone. For besides being

A THOUSAND TIMES LARGER

than the earth, and besides having eight moons shining in his sky, that world is encircled with zones of light of immense size, and of various colors. There are three, if not more, of these belts or rings, in different radiant colors, surrounding that glorious world. We can by no means imagine the splendor of the scenery there. We have radiant sunsets even here, at times, in this dim and dusky world of our own, reminding us of the unspeakable glory that "eye hath not seen." But what are the most beautiful scenes of earth compared with the glory of such a world as Saturn? And yet some puny mortals on this dim sphere of earth doubts whether Saturn is inhabited. Reason suggests, rather, that in that highly favored world there is a race of beings probably akin to angels.

And now, from the immense, may I ask you to make a sudden descent with me to the minute. In doing so I hope we shall not lose the impression of the immense. But a little study of the minute in creation will bring us, I think, to the same conclusion in reference to the habitation of other worlds.

Take a glance, then, at the animal creation. The myriads of living creatures that abound in our own world are highly suggestive of life and enjoyment elsewhere. This is true, whatever opinion we may have as to the original source of life. It may be law, or chance, or evolution, or what you will, without the action of a living, personal Creator. Or we may believe that behind all law, and chance, and evolution, there is a divine Creator, from whom all things proceed. This last is my own assured belief. But both views tend to the same conclusion. If life comes by mere law, then that law

WILL OPERATE EVERYWHERE

as well as here; and the immense amount of animal life will strongly suggest life in other worlds. Still more, if we believe that life comes from a living, personal Source, that gives us a strong suggestion that He delights even in sentient existence. Thus, having provided so many worlds where living beings might be sustained, it would not be easy to believe that He has made such abundant opportunities for dispensing happiness, and then deliberately abandoned them. This course would be contrary both to reason and benevolence.

And I think that the more we look into the profusion of life all around us, the more strongly we shall be brought to this conclusion. Not only are herds and flocks scattered over the plains, but the atmosphere and the ocean are full of the throbbings of life and enjoyment. Even if it were a principle only, and not a Person, that ordains life here, it would be hard to believe that such a principle is quite inoperative in other realms of nature. If, in walking through a forest, you

PLUCKED A LEAF AT RANDOM,

and found it teeming with insects, you would hardly imagine that to be the only leaf in the whole forest distinguished by animal life. So it is not reasonable to believe that other planets, as suitable apparently for habitation as ours, are not equally the scenes of life, activity, and intelligence.

This view is confirmed, too, by the endless variety of creatures that have been called into being. Why have we so many species of countless millions of creatures that burrow in the earth; that float in the air; that sport through the caverns of the ocean? As Wesley very sensibly asks: "What use are they of? If there be eight thousand species of insects, who can tell us of what use seven thousand of them are? If there are four thousand species of fishes, of what use are more than three thousand of them? If there are six hundred sorts of birds, of what use are five hundred of these species?"

I cannot answer Wesley's difficulty except on the supposition already advanced, namely, that the Creator delights in sentient existence; and also in the further supposition that he delights in variety. These principles, so universal in their operation here, are surely not inoperative in other realms of creation; and so the conviction grows that other worlds are the scenes of life as well as our own.

Consider, further, the extremely beautiful organization of some of the smaller animals. The care and skill exhibited in the construction of some of the insects is marvellous indeed, and can be appreciated only by laborious, microscopic investigation. In fact,

THE BEAUTY AND PERFECTION

of the lower animals seems to increase in proportion as their relation to man becomes remote and uncertain. Swamerdam says: "After an attentive examination of the nature and anatomy of the smallest, as well as of the larger animals, I cannot help allowing the least an equal, or perhaps a superior, degree of dignity." Thus it would appear that when our relation to the animals ceases, or is too remote to be discerned, they are still created for their own sake, and for the delight of Him who made them. It would be hard to believe, then, that He who diffuses life so liberally here, and who so delights in it, has not also diffused life in various forms through other planetary worlds.

May we descend one step farther in the direction of the minute? May we turn our eyes for a moment on the worlds of animalcules? And here we find the same principle mentioned a moment ago, that the farther we go into the minute

THE GREATER WONDERS

we behold. The existence of such creatures could never have been suspected but for the invention of the microscope. To Leuenhoeck is generally awarded the credit of that wonderful invention. With a very rude instrument of his own design and workmanship, that acute Dutchman, who has been styled "the prince of microscopists," introduced us to new worlds of wonder. He demonstrated animalcules to be ten thousand times smaller than a grain of sand. But his genius was far ahead of his observation; for he suspected some of these creatures to be ten million times less than a grain of sand; and the more perfect instruments of our time have gone far to verify his suspicion. When magnified

FIVE HUNDRED THOUSAND TIMES,

they appear but as a visible point. It has been computed that a drop of water accommodates with ease as many animalcules as there are human inhabitants on our globe. This is no mere fancy, but the result of patient, scientific observation.

These diminutive beings have a great variety of form and organization, while in size they differ as widely as elephants differ from spiders. Some of them are creatures of the most beautiful structure. Small as they are, they have eyes, and bloodvessels, and stomachs, and a nervous system.

Then they are endowed with most surprising vigor and activity. Some of them would appear to require no rest whatever. Ehrenberg, who observed them at all hours of the day and night, found them always active, and so concluded that they had neither rest nor sleep. In number they surpass all computation and conception. Almost all vegetable matter is impregnated with them; they abound in every part of the earth; they are found in all depths of the ocean; a leaf, a drop of water, or

A GRAIN OF SAND

gives them a convenient home; myriads of them lodge between our teeth; we daily receive millions of them into our stomachs; armies of them dash in full tilt through our viens.

Most probably these creatures have perceptions, sensations, and enjoyments suited to their modes of life. Speaking of his observation of the corolla of a flower, St. Pierre says he found it "composed of an admirable substance, studded with brilliants, and shining in the most lively colors." He adds: "The beings which live under a reflex thus enriched must have ideas very different from ours of light. A drop of dew, filtering in the capillary and transparent tubes of a plant, presents to them

THOUSANDS OF CASCADES;

the same drop, fixed as a wave on the extremity of one of its prickles, an ocean without a shore; evaported into air, a vast aerial sea."

Sir John Hill says: "I distended the lower part of a carnation, and, placing it in a full light, could discover troops of little insects frisking with wild jollity. Adapting a microscope to take in at one view the whole base of the flower, I gave myself the opportunity of watching what they were about, for many days together. Thus I could discover their economy, their passions, and their enjoyments. The base of the flower extended itself to a vast plain; the slender stems of the leaves became trunks of so many stately cedars; the threads in the middle seemed columns of massy structure; the narrow spaces between were enlarged in walks, parterres, and terraces. On the polished bottom of these, brighter than Parian marble, walked in pairs, alone, or in larger companies, the winged inhabitants. These, from dusky little flies, were raised to glorious, glittering animals,

STAINED WITH LIVING PURPLE,

and with a glossy gold that would have made all the labors of the loom contemptible in the comparison. I could, at leisure, as they walked together, admire their elegant limbs, their velvet shoulders, and their silken wings; their backs vieing with the empyrean in its blue, and their eyes out-glittering the little planes on a brilliant; above description, and too great almost for admiration. I could observe them here singling out their favorite females, courting them with the music of their buzzing wings, with little songs formed for their little organs, and leading them from walk to walk amid the fragrant groves. Here were the mystic shades of the poet's fancy realized."

Now to what do these remarks tend, and what is their bearing on the habitation of the planets? Surely this: that it is almost beyond belief that the pleasures of existence are

SO LAVISHLY DIFFUSED

throughout the minute in creation, but that solitude and death have universal sway over all the immense in the same creation. Surely it is no deduction of reason, but a mere bound of imagination to suppose that He who converts a drop of water or the petal of a flower into a habitable world, full of life and enjoyment, has made so many opportunities of doing like things on a vaster scale elsewhere, and then neglected such opportunities. I would conclude, rather, in the noble words of Chalmers, that "yon planetary orbs are so many worlds, that they teem with life, and that the mighty Being who preside in high authority over this scene of grandeur and astonishment, has there planted the worshippers of His glory."

I know not what objections may be raised to this doctrine of planetary habitation. I can conceive of two, which may be noticed in a few words.

Some, perhaps, will imagine that if this doctrine is true, the Bible would have made some reference to it. But a little reflection will show that this could not reasonably be expected. There are far more useful things than this on which the Bible is silent. The Bible gives no hint of

COAL OR GAS OR OIL

being in the earth; but they are there, and we have discovered them. The Bible told us nothing of the use of steam, or how to harness electricity to our will; but these tidings we have found out. The Bible did not tell us how to make a telescope, whereby we might see a system in every star; or a microscope, whereby we might discern a world in every atom; but we have discovered how to do these things. The Bible did not tell us that there are animalcules in drops of water, or that there are living beings in the stars; but the animalcules we have found by discovery, and the inhabitants of other worlds we think we have found too—not by discovery, but by a fair process of reasoning. No; the Bible was not given to teach such things as these, however interesting or useful they may be. The Bible does not anticipate either the discoveries of science or the deductions of philosophy. Its chief mission is to teach us the way to attain

THE HIGHEST MORAL EXCELLENCE

here, and endless bliss hereafter. These other secondary questions are left to our ingenuity; and so, by being thus thrown on our own resources, the race is developed from age to age.

Another possible objection is the supposed temperature of some of the planets. How can life be sustained on such a planet as Mercury? In proportion to her nearness to the sun that world must be so hot that a bar of iron would instantly melt in her climate. Or, taking the opposite extreme, how can life be sustained in Neptune? That world is thirty times farther removed from the sun than our earth is; what immeasurable cold must prevail there. Then between these two extremes there are many uncomfortable, if not insupportable, degrees of heat and cold.

I think there are two answers to this objection. In the first place, as intimated before, temperature is not determined solely by nearness to the sun. As a matter of fact, we ourselves are as near the sun in winter as we are in summer. A further fact is, that if you rise

A VERY FEW MILES

above the earth, you die of cold. The mountain climbers know how cold it is in the higher altitudes. Thus the condition of the atmosphere, even more than distance from the sun, determines the temperature.

You can very well conceive, then, that Mercury might be a comfortable enough world. She might be shielded from the sun's fierce heat by an atmosphere exactly adapted to her position. If we should find such to be the case, we would recognize it simply as one of the beneficent adaptations found everywhere in nature.

And on the other hand, Neptune may possibly not be a cold world at all, nor a dark world, though so immensely distant from the sun. He may have an atmosphere so adapted for absorbing and radiating the sun's heat that he is a comfortable abode. And so with light as well. It is easy to imagine that there may be compensations both in the special circumstances of that world, and in the

ORGANS OF VISION

of the inhabitants. Besides, the ordinary vocations of that world may not require an intense light. So there may be brighter worlds and darker ones. The brighter ones may be more devoted to activity, and the darker ones to repose; yet both may be happy in their own way. The variety of life and occupation which we see in our own small world may well suggest much greater variety elsewhere.

Besides; though the temperature be as extreme as you can imagine, may not the inhabitants be specially adapted to the conditions in which they are placed? We see striking examples of such adaptation in our own world, only in cases less extreme. We see how many animals take on furs for the winter, and cast them off in summer. We know how animals taken to the far north grow coats of fur to protect them from the cold, such as they never took took on before; but if you bring those animals down to warm regions, they lose their coats, and never take them on again. Such compensations are so universal here that we can imagine how much more radical they may be in worlds where they are so much more needed. In the matter of light, we can see that Neptune may have ample compensation in various ways. For one thing, the dwellers in that world are used to the conditions that prevail there, and that makes an essential difference. We would not like to go back to

THE TALLOW CANDLES OF OUR FATHERS;

but it is doubtful if our fathers were not as happy with their tallow candles as we are with our electric light. Or, the inhabitants of Neptune might have "larger eyes than ours," in a literal sense, and thus extract from the surrounding twilight practically as much light as we have. A little more breadth of view will show that other worlds, seemingly with less advantages, may be in no way inferior to our own.

You will probably contend, however, that no such law of adaptation will ever apply to such extremes as prevail in Mercury and Neptune. But we have really a very limited conception of possibilities of this kind. In this world of ours we have but few modes of existence that might suggest larger possibilities elsewhere. And yet we have some striking suggestions, if we would but learn what they teach us.

Who could have imagined that an animal could live in water, if we had not seen it? Such a thing would have seemed to us just as impossible as that an animal could live in fire. Then how do we know that it is impossible to live in fire? We do not know that it is impossible. The

FABLE OF THE SALAMANDER

may be something more than a fable. It may be a hint of a normal mode of existence in some other world. It has seemed to me that we may have a suggestion of this very thing in the case of the three faithful Hebrews who were cast into the burning fiery furnace. That strange story some would explain away, simply because they cannot account for it. Let us not be rash in thus explaining things away. That wonderful record may be an indication of a similar normal state of being elsewhere. When this fleshly body is changed into the spiritual body, for aught we know, it may have the capacity of living in fire. The angels that come and go between heaven and earth seem to have just such a capacity. How, indeed, could they survive without it? In passing through the intermediate spaces we think they must encounter extremes of heat and cold more intense than any instrument of ours can measure. But it seems they are impervious to all such extremes. So, then,

THE DWELLERS ON MERCURY

have only to be endowed with a similar body, and that world, though heated—not seven times, like Nebuchadnezzar's furnace, but seven hundred times—may be a congenial home.

As to the order of beings that may inhabit other worlds, a hint or two may be in order. We have seen that they may be organized of such indestructible material that they may exist in conditions that would be fatal to ourselves. And, judging from the diversity of organization in our own world, we may well believe there may be immense diversity in other spheres. At the same time, I have the idea that there may be a fundamental unity. I have the idea that the human form is the ideal form for all worlds. We know that this human form, as seen here, is sometimes terribly marred by toil, and suffering, and sin; but we know also that it is capable of wonderful, beautiful development. Sometimes we see

SUCH A BEAUTIFUL HUMAN FORM

that we instinctively think of a beautiful and perfect world. When angels appeared in this world they appeared as men, but with a higher type of the human form. Sometimes, as in the visions of Isaiah and St. John, they have wings; at other times they appear in dazzling brightness. It may be that the dwellers in all worlds are really men, but of different races and types. This conception of a universal humanity brings us into kinship with intelligent beings everywhere. For what are these worlds after all but the many mansions of the Father's house?

And so, from such considerations as these, we believe there are possibilities of development and expansion of which in this restricted world we can have but a poor idea. The worm that crawls over a clod can know but little of the capacity of the eagle that soars in the blue heavens.

"This is the bud of being; the dim dawn;
The twilight of our day; the vestibule;
Life's theatre as yet is shut."

CHAPTER XIII.

NIGHTLY APPEARANCE OF THE HEAVENS.

Planets that are visible—The fixed stars are suns—Clusters—Description and chart of the heavens.

AND now we would reverently step out into the infinity of the stars. I say the stars, as distinguished from the planets. Up till now we have been treating of the planets only; that is, the bodies like our earth that circle round the sun. And we have often spoken of these planets as stars, for in a popular sense they are stars. When we look at the heavens at night we see a multitude of stars, and we speak of them as though they were all of the same order. But there is really a vast difference. In the whole

VAULT OF HEAVEN

we can sometimes see four or five planets; never more. But these are practically stars as well as the others, for they shine with all the rest, and there is no striking difference in their appearance. You will notice the twinkling of some of the stars; these are the ones that are not planets.

Of the planets that are visible, you cannot but notice Venus, if it is the time for her to be seen; often she is not visible at all. You have to remember, then, that of all the stars we see at night, not more than four or five are planets. To-night, while I write, not one of these planets is visible in the northern sky.

What, then, are those myriads of stars that we see nightly shining in the firmament? Those are the fixed stars. They are so called because they are fixed. They do not move round the sun as the planets do; in fact, they have no direct relation to the sun at all. Those stars are really suns themselves. Why, then, do they appear so small and faint? That is because they are so far away. The law is, that the farther distant any object is removed, the smaller it will appear. Those stars, then,

ARE REALLY IMMENSE SUNS,

many of them larger than our own; but they are placed at such vast distances from us in space that they appear to us only as stars. You remember we said that to the dwellers on Neptune the sun appears but as a star. So those other suns appear to us but as stars. For ought we know, each of them may have planets swinging around it, like our own sun; but if so, they are far too distant ever to be seen from the earth.

We do not wish, however, just yet, to notice the wonders that the telescope reveals. We are first of all taking a survey of the heavens as they appear to the naked eye. If you are accustomed to look at the stars with attention, you will have noticed certain very bright stars in different quarters of the sky, and you will have noticed certain bright clusters of stars. And all the stars have an apparent motion

FROM EAST TO WEST,

just as the sun has. But in the case of the stars, as well as of the sun, the motion is only apparent. The stars remain steadfastly fixed in their place as the sun does. The apparent motion is caused by the real motion of the earth as she turns on her axis from west to east.

You will also have noticed that the stars have changed their position a little from night to night at the same hour. This is caused by the earth's revolution around the sun, which changes her relative position to the stars a little every night. If you make a

CHART OF THE HEAVENS,

say for to-night at ten o'clock, you will notice that by to-morrow night there will be a slight change, and in a week the change will be considerable. Therefore, charts that would enable us to identify the stars, have to be published at short intervals.

Mr. Garrett P. Serviss lately published a series of such charts in the *Christian Herald.* With each chart he gave a graphic description of the stars as they then appeared.

By the courtesy of the *Christian Herald*, I am enabled to give here one of these charts, with the corresponding article. The sketch and article relate to the heavens as they were seen some time ago, and of course do not apply now. This graphic presentation of the matter, however, may possibly arouse your interest to a more stated observation of the stars. If you have no special inclination for such a study, you can pass this chapter by.

Here is the article and chart by Mr. Serviss:

HOW TO KNOW THE STARS AND CONSTELLATIONS.

By GARRETT P. SERVISS.

The circular chart shows the position of the constellations at ten o'clock. No planets are seen, because, with the exception of Neptune, which is only visible with telescopes, they are all in the morning sky. The chart is so drawn that the centre of the circle represents the zenith. Around the edge the four principal points of the compass are indicated, and in consulting the chart the observer should hold it in such a position that "south" is at the bottom when he faces south; "north" is at the bottom when he faces north, and similarly with "east" and "west." By observing this precaution, and remembering that

THE CENTRE OF THE CHART

is overhead while the edge represents the complete circle of the horizon, it will be easy to recognize the various constellations and the brightest stars that bear individual names. Through the centre of the chart from north to south runs the meridian. When a star is on the meridian it is exactly over a north and a south line, drawn through the place which the observer occupies on earth. Since the stars, like the sun, appear to

REVOLVE WITH THE HEAVENS

from east to west once every twenty-four hours, in consequence of the actual rotation of the earth on its axis from west to east, it follows that all the stars must in turn cross the meridian, half of them at night and the other half in the daytime. We cannot see the stars in that half of the heavens wherein the sun chances to be between sunrise and sunset, but as soon as the sun has gone down, the opaque body of the earth acts like a screen, shutting out his light, and then the stars in the celestial hemisphere opposite to that where the sun is, become visible, and

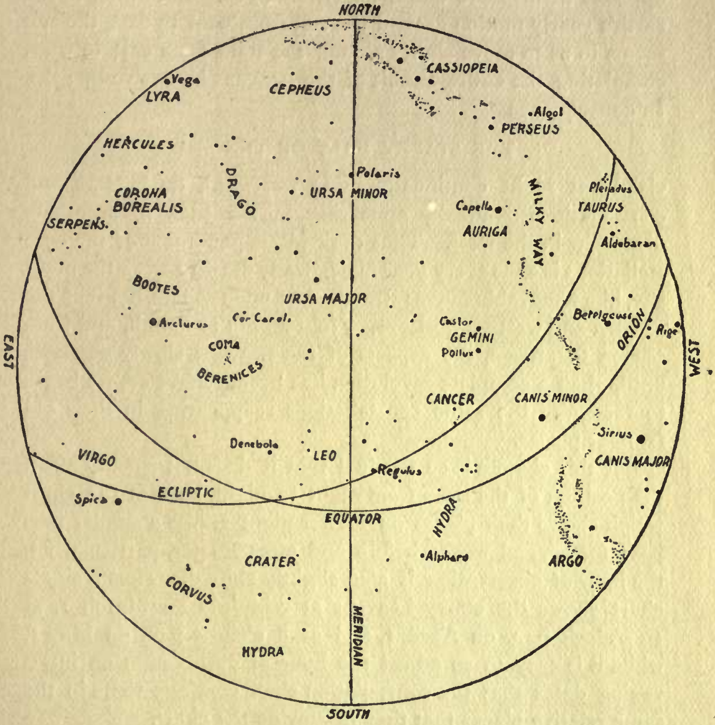

NORTH
Vega
LYRA
CEPHEUS
CASSIOPEIA
Algol
PERSEUS
HERCULES
DRACO
Polaris
URSA MINOR
CORONA BOREALIS
SERPENS
Capella
AURIGA
MILKY WAY
Pleiades
TAURUS
Aldebaran
BOOTES
URSA MAJOR
Arcturus
Cor Caroli
COMA BERENICES
Castor
GEMINI
Pollux
Betelgeuse
ORION
Rigel
EAST
WEST
CANCER
CANIS MINOR
Sirius
CANIS MAJOR
Denebola
LEO
VIRGO
Regulus
ECLIPTIC
Spica
EQUATOR
HYDRA
CRATER
Alphard
ARGO
CORVUS
MERIDIAN
HYDRA
SOUTH

CHART OF THE HEAVENS.

Specially prepared for the "Christian Herald" by Garret P. Serviss.

we see them arrayed in brilliant constellations, marching from east to west, and pouring in sparkling hosts across the meridian until the approach of daylight again shuts them out.

If the earth simply rotated on its axis once a day, without

REVOLVING AROUND THE SUN

once a year, then the sun would appear to stand for ever fixed in one hemisphere of the heavens, and only the stars in the opposite hemisphere would be visible to us. But owing to the earth's yearly motion around the sun from west to east, the sun seems to us to move slowly among the stars from east to west, completing the entire circuit of the heavens in twelve months. In consequence

THE STARRY HALF OF THE SKY

visible at night continually shifts westward, fresh stars and constellations gradually appearing in the east, while others disappear in the west. Thus the endless panorama of the constellations is once every year majestically drawn across the night sky, like a movable canvas stretched, as upon rollers, between the eastern and western horizons. From month to month, and from season to season, the aspects of the heavens slowly changes, until, when a complete revolution has been performed, we begin to recognize the same constellations reappearing in their old familiar places.

But this change is so gradual that it does not greatly affect the position of the stars from night to night, so that the chart which shows their places on Easter night serves a similar purpose for several weeks before and after Easter, particularly if the hour of observation is also slightly shifted. Thus a single chart shows the starry heavens at midnight on March 1, at 10 o'clock p.m. on April 1, and at 8 o'clock p.m. on May 1, while it is easy to so adjust the hour of observation on intervening dates that the constellation shall continue to be in the same relative places that they occupy on the chart.

When once the observer has learned to recognize the constellations by

THEIR MOST SIGNIFICANT STAR,

and the imaginary figures they mark out, he will be no longer troubled by their slow change of place.

The curve on the chart marked "Equator" represents the equator of the heavens which lies directly over the earth's equator. The "Ecliptic" shows the annual path of the sun in his apparent revolution through the heavens, described above. It is a great circle inclined about 23½ degrees to the plane of the equator. It crosses the equator at two opposite points, called equinoctial points, because when the sun reaches them day and night

ARE OF EQUAL LENGTH

all over the earth. The crossing point on the chart, in the constellation Virgo, is the autumnal equinox, at which the sun arrives about the 21st of September. The paths of the planets and the moon all lie near the Ecliptic, within a few degrees on one side or the other. In future charts, when those parts of the day in which some of the principal planets happen to be, are represented, I shall indicate the planets' places among the stars.

Turning now to the constellations visible at the present season we see the Ursa Major, the Greater Bear, is almost overhead in the north, the familiar figure of the Dipper, by which the constellation is usually recognized, being just east of the meridian. The two stars on the

OUTER SIDE OF THE BOWL

of the Dipper are called the Pointers, because an imaginary line drawn through them nearly hits the North Pole Star, or Polaris. But the constellation Ursa Major is much larger than the Dipper. The triangle of small stars west of the Dipper marks the head of the celestial bear, while the three not inconspicuous pairs of stars overhead, toward the south in the direction of Leo, show the position of his feet. The handle of the Dipper

SERVES HIM FOR A TAIL,

and at this season, as we look at him with our faces to the north, he appears to be walking on the ceiling.

Looking next at the Pole Star (Polaris), it will be noticed that a row of rather faint stars, ending in a group of four, one of which is about as bright as Polaris, forms the figure of a smaller dipper, with its handle bent the wrong way. This constitutes the better part of the constellation Ursa Minor, the Lesser Bear.

Following the trend of the handle of the Great Dipper towards the south-east, the eye is led to the very bright star Arcturus, sung by the poet who wrote the Book of Job. In certain states of the atmosphere this great star has a flaming color that makes it a startling object. We have evidence that it is a sun at least

A THOUSAND TIMES AS BRIGHT

as our sun. It is the chief star of the constellation Boötes, the Bear Driver.

West of Arcturus glimmers the silvery little constellation Coma Berenices, fabled to be the transfigured locks of Queen Berenice of Egypt. Eastward from Arcturus shines the beautiful circlet of Corona Borealis, the Northern Crown.

Between Ursa Major and Ursa Minor winds the great dragon Draco, whose head is indicated by a conspicuous diamond-shaped figure near the north-eastern horizon. Over on the north-western side of the meridian, under Polaris, is Cassiopeia,

A BEAUTIFUL CONSTELLATION,

easily recognized by the irregular "W"-shaped figure marked out by its five principal stars. To the right of Cassiopeia, directly in the north, is Cepheus, not a very bright constellation, but worth noticing, because it forms one of the so-called "Royal" group, including Cassiopeia, Perseus, and Andromeda, the traditional history of which will be recounted in a later article, when they occupy a more prominent position in the sky. Through Cassiopeia runs the stream of the Milky Way, and, following its course, the eye catches at one point the confused glitter of

A MASS OF MINUTE STARS

called the Sword Hand of Perseus. Perseus himself appears a little farther on, immersed in the Milky Way, with his brightest star, flanked by a row of smaller ones on either side, making a well-marked bow-shaped figure. Not far off, downward toward the horizon, is the wonderful "demon" or "winking" star Algol, which it has recently been demonstrated, possesses a close, invisible companion of huge size, which, at regular intervals, partially eclipses the light of the bright star—

A FRIGHTFUL COMBINATION,

since both Algol and its mysterious comrade exceed our sun in size.

To the left of Algol scintillate the Pleiades, the famous Seven Stars, one of which, before the invention of the telescope, was fabled to have been lost. These are in the constellation Taurus, and the V-shaped figure to their left, called the Hyades, also belong to Taurus. The bright reddish star in the Hyades is Aldebaran. Half-way up from Aldebaran to the Great Dipper appears the brilliant Capella,

A PURE WHITE STAR,

the chief gem of the constellation Auriga. South of Auriga, and fast nearing the horizon, is the mighty hunter Orion, with Betelgense flaming on his shoulder, and Rigel on his foot, while the three matched stars of his belt gleam like a decoration. Following out the line of the belt towards the south-east, the eye comes to the prince of stars, Sirius, in the constellation Canis Major. No star in all the heavens equals Sirius in brightness.

Above Sirius, toward the left, is the bright star Procyon in Canis Minor, and above that again are the twin stars of Gemini, Castor and Pollux. Next east of Gemini appears the little constellation Cancer, with a faintly glimmering cluster called the Manger. Then further eastward,

IN MID-HEAVEN, IS LEO,

easily recognized by the figure of a sickle standing upright on its handle, with Regulus at the bottom. Denebola, off toward the east, also belongs to Leo.

South of Leo is the long winding constellation of Hydra, the longest in the sky, the star Alphard marking its heart, and a little group to the west of Leo, and below Cancer, its head. Standing on the coils of Hydra are Crater and Corvus, and east of Corvus sparkles the beautiful white star Spica, in the constellation Virgo.

CHAPTER XIV.

THE SWIFTEST THING WE KNOW.

Motion of light—Marvellous Velocity—A constant unerring law—History of its discovery—Jupiter's clock—A curious calculating machine—Man himself the greatest wonder—Hint of immortality.

WE are now preparing to go out into the immensity of the starry hosts, and widen our survey of creation by the aid of the telescope. Preparatory to doing so, we wish to call your attention to the marvellous velocity of light. This we shall find useful in indicating some of the distances of the stars.

There is no fact of more importance to astronomers than the rate of speed at which light is known to travel. It is really the swiftest thing we know. You might suppose that sound travels quickly. You see a man at a distance strike some object with a hammer, and you notice that there is a very short interval before you hear the sound. That is the time that sound takes to travel to your ear. But that is

A CRAWLING AND CREEPING PACE

compared with the motion of light. As we said before, light would move seven times round the world in a second. This is really bewildering ; but it is true.

This motion is so rapid that for a long time it was supposed that light effects were instantaneous. Later, when it was discovered that light has really a rate of motion, many attempts were made to discover the rate at which it travels. It was a long time before these efforts met with complete success. At length, however, the feat was actually accomplished beyond possibility of mistake.

This matter is so interesting, and in this connection so useful, that I have thought it well to give at length the history of this great discovery. In the study of the heavens we have to do with vast distances which we can realize best by indicating the time required by light to travel from one object to another through the immensities of space. Besides,

THIS ASCERTAINED MOTION OF LIGHT

gives us a conception of the constancy and beauty of nature's laws; and hardly less do we marvel at the faculties bestowed on man whereby such laws are discovered.

Here, then, is an article from the pen of Mr. W. E. Garrett Fisher, which puts the matter in a very popular way, and deals only with ascertained facts:

"To the natural man it may seem as absurd to assign any finite speed to light as to attempt to limit the rapidity or the freedom of thought. As far as our unaided senses can tell us, both are practically instantaneous. No terrestrial experience can help us to gauge the velocity of light without the help of very delicate and refined apparatus. M. Cornu, who died in Paris at the end of last week, made his chief reputation by the skill with which he devised such an apparatus, and therewith

CARRIED OUT EXPERIMENTS

which finally settled the speed of light with an accuracy that later research has only confirmed. The story of the slowly widening investigations which culminated in his work, with the lesson that they have taught us, is worth reading.

As far as we know, 'starry Galileo, with his woes,' was the first to try to verify the suspicion—as old, perhaps, as Aristotle—that light was not really free from the conditions which trammel ordinary motion. From a very early time it was obvious that the closely related

PHENOMENON OF SOUND

was by no means instantaneous in its passage from place to place. The first man who watched one of his fellows chopping wood half a mile away must have noticed that the sound of each blow was by no means synchronous with its apparent time as far as the eye could fix it. Often the woodman's axe is visibly poised over his head at the precise moment when the sound of his last blow reaches the onlooker.

We cannot tell who was the first obscure philosopher to conceive that even light might take an appreciable time to travel to the observer. The earliest theory of sight, which regarded it as the result of a kind of intangible feeler reaching out from the eye, did not allow any consideration of speed; but the sound theory, which held the field down to the beginning of the last century, and considered that light was a material emanation from all luminous bodies, at once involved the notion of the speed with which these 'corpuscles' travelled. Galileo then first seriously tried to measure the speed of light. His principle was sound enough, but it was impossible for him to solve a problem of

WHOSE EXTREME MINUTENESS

he had no conception. He stationed two observers a couple of miles apart at night, each armed with a dark lantern. One of them suddenly darkened his lantern, and the other was instructed to do the same the moment that the first light disappeared. Galileo reasoned that if light really took a finite time to cross the distance, it would be measured by half the interval between the darkening of the first observer's lantern and the disappearance of the second light from his gaze. It was a perfectly sound argument; but as the time in question was about

ONE FIFTY-THOUSANDTH PART OF A SECOND,

it is no wonder that the observer failed to detect it. Yet it is on a quite similar plan that all the modern experimental determinations of the speed of light have been made.

The first approximately correct guess at the velocity of light—so immensely surpassing any other speed with which mankind was familiar—was made by an astronomer in a quite different way. Römer, a Danish astronomer who had settled in Paris, was dreadfully perplexed in the second half of the seventeenth century by the inaccuracies in the motions of Jupiter's satellities. When the ascertainment of the longitude at sea was the chief object of astronomical ambition, a favorite method was to construct accurate tables of the eclipses of Jupiter's satellities. If the Greenwich time of any given eclipse be calculated in advance, the sailor who observes that eclipse in the centre of the Atlantic at once knows the difference of time—and therefore of longitude—between Greenwich and his own position. Römer set himself to

CALCULATE SUCH TABLES,

but he was puzzled by a constantly recurring inaccuracy in the apparent motions of the satellities. They seemed to be losing time at one part of their career, and gaining it at another. After a time Römer made the happy discovery that

THE INGENIOUS CLOCK

thus formed by Jupiter's system went fast or slow in accordance with the earth's annual revolution about the sun. When the earth was nearest to Jupiter, the eclipses were up to time; when it was at its farthest point away from the giant planet, they were as much as twenty-two minutes late—so, at least, Römer concluded from the rather imperfect observations which he had to depend upon. Suddenly he hit on a brilliant idea; the reason, he said, was simply that light took

TWENTY-TWO MINUTES LONGER

to come from Jupiter when he was farthest from the earth than when he was at his nearest—that it took, in short, twenty-two minutes to cross the earth's orbit.

We now know that this was the true explanation, though the time which Römer had calculated was about twenty per cent. too large; when one begins to deal with distances of the order of the dimensions of even our trifling and inconsiderable system, light takes a quite appreciable time to cover them. It takes, for instance, just over eight and a quarter minutes to come to us from the sun—in other words, if the sun were to be

UTTERLY BLOTTED OUT

at this moment, the reader would still have time to finish this article before being plunged into eternal night.

When one deals with the larger distances of stellar astronomy, the speed of light itself seems inadequate to sound the abysses of space. It has been calculated, with a considerable show of reason, that the new star in Perseus, which blazed out to our eyes a little more than a year ago, really came into existence about the time of the Spanish Armada, and that the message of light which it sent to tell us of its fiery cataclysm has taken more than three centuries to reach us, at the rate of nearly two hundred thousand miles a second. To try to realize the meaning of this simple statement is a pretty good exercise in that believing of impossible things which the White Queen—like Tertullian—thought so good for the mind.

The last step in the determination of the speed of light, of which the glory must be divided with several able physicists, by the late M. Cornu, brings us back to earth again, and incidentally provides us with a useful measuring-rod for our Solar System. Cornu, following Fizeau and Galileo, set to work to

MEASURE THE SPEED OF LIGHT

on a terrestrial scale. He applied an ingenious refinement to

Galileo's experiment, which enabled him to multiply the infinitesimal time taken by light in traversing a small distance until it became measurable with accuracy.

In the first place, Galileo's second observer was replaced by a mirror. A ray of light was sent at night from the Paris Observatory—this was in 1874, when the Ville Lumière was less smoky than it is to-day—to a mirror at Monthéry, about fourteen miles away. It was reflected, by means of telescopes and careful adjustments, back to the room whence it started. Both in going and coming it had to pass through one of the apertures in the rim of a large, finely-toothed wheel. Then M. Cornu began to turn the wheel. As long as

THE SPEED OF THE WHEEL

was so small that the ray of light was able to traverse the twenty eight miles—there and back again—before the hole through which it passed was blocked by the adjacent tooth, the light remained visible to an observer looking between the teeth. But, as the speed of the wheel was increased, the light was seen to grow fainter and fainter, till at length it totally disappeared. That meant, of course, that the wheel had turned through the breadth of a single tooth while the light was travelling twenty-eight miles. If

THE SPEED OF THE WHEEL

was still increased, the light began to appear again, as by the time it returned to the wheel a second aperture was coming into place. M. Cornu increased the speed of his wheel until he was able to make twenty teeth pass before the light got back, and to catch it on the twenty-first. From his experiments, which agree very closely with others made by independent investigators on a somewhat different principle, it is concluded that the speed of light is

186,700 MILES

per second; and this is certainly correct within 500 miles. 'The wheel has come full circle,' and the velocity of light, which was at first deduced from the roughly calculated dimensions of the solar system, now affords one of the best methods of measuring those dimensions with nicety.

When M. Cornu and his predecessors were working away so minutely in their laboratories, they were really helping to sound the depths of space, for we know the time in which light crosses the earth's orbit so exactly that the experimental determination of the speed of light gives a close approximation to our fundamental base-line—the earth's distance from the sun—than any purely astronomical measurement has yet furnished.

Another remarkable result of such work as M. Cornu's—quite unexpected at the time—is that it has provided one of the best arguments for the close relation between light and electricity which Clerk Maxwell predicted. The speed of light, as thus measured, is absolutely identical with the measured

SPEED OF ELECTRICITY,

within the limits of experimental error. There could hardly be a stronger reason for believing in the modern theory that light and electricity alike consist of waves in one ether, only differing in size. The existence of a single velocity so enormous is hard enough to conceive; it is too much to suppose that it should belong to two wholly independent sets of phenomena."

It is surely a charming and amazing thing to read of this discovery. How wonderful are nature's steady and constant laws. And to think that those distant moons of Jupiter—apparently of no use to us here—should be the means of giving us the secret of the unerring, bewildering swiftness of light. And thus we have the key to the amazing distances of the stars.

And yet, is not man himself the greatest marvel and mystery of all? To think that a being on this dull earth can grasp such laws, and use them like a calculating machine! If there were nothing else, this discovery of the motion of light might well give us a hint of immortality.

CHAPTER XV.

BALL'S BURNT OUT STARS.

The telescope—Glories undreamed of—Burnt out worlds—A dismal theory—Premises too easily assumed—Waning heat not proved—No evidence of lost stars—The stars that shine.

HAVING now become somewhat acquainted with the planetary worlds, and also with the stars that are seen by the naked eye, we would launch out into those more distant realms where we need the aid of the telescope. Here we soon learn that all the stars seen by the naked eye are but the mere outposts of creation. The telescope introduces us to new universes of glory of which we would never else have dreamed.

Before launching on these fascinating regions, I would like to clear my way a little by noticing a theory lately published by Sir R. S. Ball. His article relates to

MYRIADS OF BURNT OUT STARS

which he represents as floating through the realms of space. If such blackened cinders of worlds really exist, I would not wish to encounter them in our quest after the stars that shine.

Let us see, then, what this dismal theory is, and what the author of it has to say on its behalf. Sir R. S. Ball is certainly a popular writer on astronomy, and it has been claimed for him that he worthily fills the place lately occupied by Richard A. Proctor. But I think Sir Robert would shine with more splendor if he let these dirty cinders of worlds alone.

This author labors to show that the myriads of stars that can be seen are but a fragment of the greater universe that is dark, and therefore invisible. "It is my object," he says, "to show that the present state of science forces us to believe that there is around us

AN INVISIBLE UNIVERSE

which far more widely exceeds even that extended universe which we can see, than does our visible universe exceed that of a being whose celestial knowledge was limited to the recognition of an existence of a sun and moon."

This is sufficiently involved, but the author gets clearer as he goes on. "We are to reflect," he says, "that all the objects which we can see constitute in all probability not one thousandth, perhaps not one millionth part of the material heavens." And the author makes out this theory by supposing that "the normal and ordinary state of matter in the universe is to be cold," and that hence so many stars have

BURNT THEMSELVES OUT

as to be probably a million times more numerous than those that shine. In fact, what is visible, he says, is an "almost inconceivably small fragment of the universe that is burnt out, and therefore invisible."

Now there are two or three objections in my mind to this line of thought, which I would respectively submit in as brief terms as possible.

First of all, we cannot but be struck with this, that the one premise assumed so easily is by no means certain. Sir Robert assumes that "the ordinary state of matter in the universe is cold." But how cold ? Surely it must be a question of degree. Is there such a condition as absolute cold ? Is such a condition conceivable ? Does not our most extreme conception of cold involve some degree of heat ? And if some degree, how much ? If we may conceive of any degree of heat, may we not conceive of a larger degree, and still a larger and larger ? Is not this assumed far too easily ? It is the same assumption that is the basis of the nebular theory. But in this case much more startling conclusions follow. Sir R. S. Ball, from his one premise, draws the conclusion that "an almost inconceivable fragment of the universe" only has been saved from extinction. Ought we not to be more careful in making an assumption involving such a startling conclusion ?

ASSUMPTION OF UNIVERSAL COLD

And, certainly, the direct evidence of creation itself gives but a small hint of cold being the normal law. In the presence of countless millions of stars, which are all suns of the most intense blazing heat, how can we assume that cold is the normal order of things? Because we do not know how the heat of the universe is sustained, we may not rashly assume that it is not sustained.

Just here we have a great mystery. It has long been a habit of astronomers to look for the waning of the sun's heat. They think it must be waning, because they know of no law to prevent it. But as a matter of fact, there is no evidence that the sun's heat is waning at all. Forced to the recognition of this fact, many have tried to account for it. Nine or ten different theories have been advanced to account for the sun maintaining his heat without apparent diminution. And still we are just about where we started. We simply do not know. We are in the presence of a mystery not to be accounted for by any known laws.

For ought we know, there may be some higher law quite beyond our ken, by virtue of which our sun, and

MILLIONS OF OTHER SUNS,

have their heat sustained. I admit the uniformity of law; but that does not forbid the operation of a higher range of laws of which as yet we know nothing. And when we see the countless sun-fires that have been kindled, and are kept aflame, I think we ought reverently to hesitate before assumming that "the ordinary state of matter in the universe is cold." I submit, therefore, that Sir R. S. Ball's tremendous assumption of normal universal cold is by no means self evident, and that hence his universe of dead, useless, abandoned stars may really have no existence, except in his imagination.

But, further, if certain stars are burnt up, that is no evidence that they are lost. They might only be transformed to fit them for some new career. According to the laws of conservation of matter, such worlds do not become extinct. The materials are all there, ready to enter into new combinations, and produce, possibly, more glorious effects. Stars, we believe, have thus burned out. Once and again, we have seen "the august spectacle of a world on fire." Quite lately, we had that notable case of a star in the constellation Perseus, which suddenly increased in brilliancy from the tenth magnitude to the second. After a time its brilliancy declined, until it became but faintly visible. But has that star become extinct? There is no evidence of that. It may, for aught we know, be only in a state of preparation for a new career. Some astronomers treat the event, not as

THE EXTINCTION OF AN OLD WORLD,

but the birth of a new one. F. Legge, in a recent article in the *Academy*, speaking of this star, says: "As its spectrum showed that much of its brilliancy was due to an outburst of incandescent hydrogen gas, all astronomers made haste to agree that its appearance was the sign of some such catastrophe in the heavens as a collision between two huge masses of matter, and that we were therefore assisting at the birth of a new world, or even of a new system." According to this view, Sir R. S. Ball will find in the catastrophe in Perseus no material for his burnt out stars; and it may be doubted if he will find them in any other constellation.

We have one sure analogy that sustains this conclusion. On the authority of Scripture, we know that this world of our own will be burnt up; but we also know, on the same authority, that a new world will arise out of the ashes of the old. This will not be extinction, but renovation. And may not this be the order of procedure in all worlds? Certainly it seems more in

HARMONY WITH THE DIVINE ORDER

of progress. This one analogy is more conclusive with me than any amount of mere speculation. It certainly is not favorable to any theory of burnt out and dead stars.

But still further, this theory of Sir R. S. Ball involves the ultimate extinction of the entire universe. If the extinction is going on agreeably with his theory, the time is surely coming when the largest and most brilliant star must go out in darkness. That is its inevitable doom. For, so far as I have seen, Sir Robert's scheme makes no provision for new creations to balance the extinctions; or, if such provision is made, it is without any scientific basis. There may be, perhaps, a moral basis for new creations; but I understand Sir Robert to deal only with scientific data. So then, on his showing, the last star in the universe must be extinguished.

Besides, if the normal state of the universe is cold, as Sir R. S. Ball assumes, there surely was a time when it was really in that normal condition. It could not begin in an abnormal state. Therefore, the universe must have been cold at the beginning. But it is not cold now. Then whence the change? How did the universe come into its present condition of heat? How did the heat originate? If you ignore all idea of a Creator, still there must have been some cause for the origin of heat. Now, whatever may have been the cause by which heat was originated, is not that cause sufficient to have it sustained? If Sir R. S. Ball will ponder this thought, I think he will find no basis for his dream of universal cold.

Even if the worlds are all dying out, as Sir R. S. Ball believes, what becomes of their heat? Where does it go? Surely it is not lost? According to Professor Tyndal, heat is a mode of motion. Then may not the heat of the dying worlds be transmuted into motion or some other force? And if that is possible, may it not be transmuted back again? We fail to see why not. So, take it as you may, this idea of the universe burning itself out seems to be but a morbid hallucination.

Then notice the proportion which this theory assumes between the dead stars and those that shine. Sir Robert probably thinks that only one millionth part of the whole universe survives. His idea is, that for one star that shines, 999,990 stars are dead. That is actually the proportion which he assumes. I wonder where he got that proportion? To get any proportion at all, he would need to know when creation began; he would need to know how many stars were created; he would need to know exactly the size and brilliancy of each one of them; he would need to make a special calculation of the time each star would last; then he might arrive at the proportion of the small remnant that still continue to shine. And this small remnant, be it observed, is composed of

UNTOLD MILLIONS OF STARS

that burst upon us, and stagger us with more and more surprise with every new improvement of the telescope.

I wonder if Sir Robert has once thought of the issue to which his theory surely leads? If he had thought of it, surely he would have paused. For the theory seems to me not only unwarranted, but grotesque and hideous, and contrary to all our best instincts of progress. It turns the universe into a charnel house of dead worlds, instead of making it a display of divine power and glory.

My last objection to Sir R. S. Ball's view is, that it is too negative. What we want is, not a dismal dream of dead worlds, but the actual glory of creation brought vividly into view. This is not done by telling us that almost all the entire universe is but a mass of burnt out and blackened cinders, floating aimlessly, or perhaps destructively, through space. I wish our artist could draw upon his imagination a little, and give us a picture of about half a dozen of Ball's burnt out cinders. That would show us, perhaps better than anything else, how dreary is such a speculation.

We turn our thoughts instead to the myriads of stars that shine with undimmed, eternal splendor. If Sir R. S. Ball would be a worthy successor of Mr. Proctor, he must unfold to us the glory of the visible heavens, until the soul bows in reverent, adoring awe in presence of the wonderful works of God. We have as yet seen but the shimmer of His glory from afar. As our view widens, the marvels of creative power only becomes the more astounding. We realize that we are but in the vestibule of the palace. All the glory we see is but as the glimmer of the lamps on the walls of the eternal city.

CHAPTER XVI.

IMMENSITY AND GLORY OF THE STARRY HOSTS

Distances of the stars—Bulk and brilliancy—The Milky Way—Arcturus—Orion—Pleiades—Hercules—Perseus—Various orders of worlds—Uncounted hosts—Herschel and his poor telescope—Later telescopes—Photography of the stars—Gold dust of worlds—Suggestion of infinity—A golden dome of stars—Binary stars—Variable stars—Colored stars—Marvels of discovery—Greater glories behind.

IN very early times the sky was believed to be a solid dome in which the stars were immovably fixed like brass nails. Even yet, to the naked eye, the stars seem almost equally distant. If we look towards a city in the distance on a dark night, the city lights seem hardly to vary in distance, though there may be miles between them. So it is with the stars, only on a vaster scale; for they are separated not by miles but by millions and millions of miles. In fact the distance of the nearest of them is so vast that we cannot realize it; and the more distant ones are

LOST IN THE DIM INFINITY

of space. It is the telescope, which in early ages was not dreamed of, that has so widened our vision of the universe.

The first thing, then, that I shall try to do, will be to help you to comprehend something of the immense distances of some of these stars.

When you look at the stars with the naked eye they do not appear to have any bulk at all; they are simply mere points of light. That is because they are so very far away. You can see that the moon has some bulk, and her rim is quite clearly defined. That is because she is so near. Even Venus is seen to be a round, solid body, and her disc is pretty clearly marked. She is very much farther away from us than the moon, but as compared with the stars she is quite at hand. We might truly say that in comparison, we have Venus in our back yard, while the nearest star would be a thousand miles away. It is because of that distance that the stars seem but as tiny specks of light.

Not only is this so, but if you look through a telescope that magnifies objects two thousand times, the stars look just the same; they are still mere lucid points without any body whatever. That is to say, that if for each two thousand miles they are distant, they were only one mile distant, they would not appear larger than they do at present. And the effect is still the same when they are viewed by

THE LARGEST TELESCOPE

in the world. Yet we know that they are of immense bulk, most of them probably millions of times larger than the earth. How vastly, then, they must be distant in space, when they cannot be sensibly enlarged by the most powerful telescopes.

Again, suppose a cannon ball were fired from the earth in the direction of the nearest star, and that it continued to go on without slacking its speed, how long do you think it would be in reaching that nearest star? It would take no less than four millions of years. That is utterly astounding; such an immense distance can not be realized.

Let us, then, make another calculation. You will see now why we paid so much attention to the motion of light. It is millions of times swifter in its movement than a cannon ball. This motion of light is used by astronomers to indicate the distances of certain stars. If they speak of a ten-year star or a twenty-year star, they mean that light would travel from those stars to the earth in ten years or twenty years. But surely, you would say, no star is so distant that it needs to be designated in that way. Yes, there are stars far more distant even than those. Remember that light is so swift that it would flash round the world seven times in a second. At this rate it would come from the sun in eight minutes. How distant, then, the sun must be. Yes, immensely distant; but compared with the nearest star, the sun is quite close at hand; for light that would come from him in eight minutes, would require three years to come from the nearest star.

And yet that star is but a suburb of greater glories beyond. For there are stars from which light would not reach us in ten years, twenty years, a hundred years, a thousand years. Is this possible? Yes, and even that is not the utmost bound of the truth. The Milky Way is an aggregation of

STARS SO INFINITE IN NUMBER,

and so far away, and flung out so far into the abyss of space, that astronomers have soberly calculated that light would not cross that universe of stars in less than ten thousand years! Ah, we are almost lost now in the infinity of these starry worlds!

Let us come back, then, and make another calculation, which possibly may come a little more within our grasp. Come back to our own solar system for a moment. We saw that the outermost planet from the sun is Neptune. We saw that he is distant from the sun about 2,860 millions of miles. Double that number and you will have the diameter of his orbit. That will be 5,720 millions of miles. Now suppose the whole of this vast area of space were entirely filled wish one immense globe—a globe 5,720 millions of miles in diameter; and suppose this globe were

A SUN AS BRIGHT AS OUR OWN,

you imagine what consternation such a globe would cause in other distant worlds. How the dwellers in such worlds would be paralyzed by the appearance of this monster of light and fire.

No, nothing of this kind. If such a globe were created, there are places even within the range of telescopes where it would excite no surprise, and if suddenly extinguished, would scarcely, or not all, be missed. Such are the immense, unfathomable distances of some of those twinkling stars which we have all seen shining in the sky since we were children. Those jets of light are vast flaming suns, scattered through illimitable realms of space.

Having thus gained some conception—though a very poor conception—of the distances of the stars, we naturally think next of their bulk. And along with their bulk we may combine the thought of their brilliancy; because, other things being equal, the larger a star is, it will give the more light.

But, as everywhere else in nature, there is great diversity here. The stars differ both in size and brilliancy. We know

HOW DAZZLING IS THE SPLENDOR

of our own sun. If our eyes were not in some way shielded from his beams, he would strike us with instant blindness. Yet it is not at all unlikely that, compared with some other suns, this one of ours is dusky and dim. Just as our earth is a small, dim world among the planets, so our sun may be a small, dim sun among the stars.

And this idea is borne out by what we can observe of the bulk and brilliancy of the stars. We find that in going out into space, the very first star we meet gives four times as much light as our sun. This is Centauri, the nearest of all the stars. It seems a small star, yet it is so much brighter that the sun. We find, then, that Vega gives forty times as much light as the sun, while Sirius gives fifty times as much, and Arcturus gives two hundred times as much. Now, then, imagine these masses of matter to be moulded into one sun; yet such a universe of a sun would be only equal to Arcturus. So our sun begins to lose something of his supremacy in the presence of these greater glories.

What is more, the stars we have referred to are near in comparison with some, which, even to the naked eye, are remarkably bright; so their size and brilliancy can be somewhat closely estimated. But then, the depths of space are strewn with millions more, only too far away to be accurately observed.

It would be strange that, if among the uncounted millions of stars so far away, there may not be many of far greater size and splendor than those near at hand. Yes, it is possible and even likely, that Arcturus may be a small and dingy star in comparison with the unimagined splendors of other stars millions of times farther away. Ah! we are getting lost in the immensities again. Let us, therefore, turn back, and give our attention to some other phases of the stars less bewildering in vastness and glory.

In looking at the heavens with the naked eye you see several clusters of stars; and in those clusters, other stars are revealed by the telescope. The main clusters or constellations are Hercules, Orion, Perseus, and Pleiades. You will at once recognize Orion and Pleiades as being mentioned in the Book of Job; and just as Job saw them of old, they still remain. The name of Perseus will be familiar to you, because of the star that appeared in that cluster some time ago, and behaved in such a curious way. From being faint, it began to grow brighter until it became

A STAR OF MARKED BRILLIANCY;

then, after awhile, its brightness waned, and gradually it grew less, until the star almost disappeared. This is one of many stars that act in this curious way.

But we are thinking of the clusters, and we have named four of the most notable ones. And yet most of these clusters are hardly worthy of that name; for they are not clusters in fact, but only in appearance. You can understand that being so far away, a number of stars might be placed nearly in the same line from your eye, and so they would appear quite close together; yet, in actual distance, they might be millions of miles apart. So the groups of stars that we call clusters are, in some cases, only so in appearance, just as the lights of a city in the distance appear quite close, yet may be widely divided.

In other cases the stars in certain groups are comparatively near together, and sustain special, close relations to each other. Orion, the most glorious constellation, has been supposed by some to be a complete system in itself, with stars revolving round the centre. Others have thought this constellation may contain different systems, independent of each other. So little, after all, do we know of these universes of stars.

Let us turn our attention now to the number of the stars. The dome of heaven seems filled with them. At the first glance, they might seem past all counting. It is no wonder they have often been taken as a symbol of a great multitude. When Abraham was promised a numerous seed, he was told that they would be as numerous as the stars of heaven. To the simple oriental mind, that would be a sublime symbol of an uncounted host.

But the stars are not really so numerous as at first sight they might appear. If you have a clear night, and good eyesight, and a large stock of patience, you can count the stars. Instead of doing so, you will likely prefer to take the estimate of others. I may say, therefore, that in this hemisphere of the sky, some have counted 3,000 stars. Others, with perhaps a clearer night or keener sight, have reckoned the number at 4,000. Let us, then, accept 4,000 as the number to be seen in this half of the whole sphere. The other half of the sphere will contain, of course, about 4,000 more. The total number of visible stars in the entire dome of the sky will thus be about 8,000.

These 8,000 stars, however, are but the outposts of creation. They represent but a dim corner of the glorious universe. They are but the suburbs of the golden city. They are only the ante-room of the palace. We have barely seen the shimmer of the golden gates. The telescope reveals

UNIVERSES OF STARS

of which man never before had dreamed. And with every new improvement of the telescope new splendors of creation burst on our astonished sight. In no respect do we encounter such stupendous marvels as in the bewildering number of these uncounted hosts.

In the year 1792, Dr. Herschel was making an observation of the stars. You can imagine what a poor instrument was the telescope of a hundred years ago. Yet we find that in forty-one minutes there passed over the field of view in Herschel's telescope no less than 258,000 stars

Where are now the eight thousand stars seen by the naked eye? They have dropped out of sight. They are but a minute fraction of the myriads of stars that flash upon us through a very small telescope. And this is but the beginning. We have barely entered the gateway of the starry worlds.

We have seen greater marvels since Herschel's time. The last hundred years have developed wonderful improvements in the telescope; and every new development reveals new glories. Lord Rosse's telescope marked a new era of discovery; and later and far larger instruments have widened our field of vision almost, as we might say, to infinity.

Calculations have been made from time to time as to the number of stars that come within range of the telescope. With the improved instruments of some years ago the estimate was about eighty millions. Now compare

THOSE EIGHTY MILLIONS

seen by the telescope with the eight thousand seen by the naked eye. Suppose the eighty millions were brought near enough to be seen by the naked eye, then for each star we see now we would see ten thousand. Just ponder that fact. Imagine that for each star you see in the sky to-night there were ten thousand more. That gives you some idea of the boundless immensities of creation.

And yet, of late, we have gone much farther. You see at night that irregular band of whitish looking cloud stretching across the sky. That is the Milky Way. For a long time it was believed to be a mass of vapor, very far away in space; and some believed it to be the nucleus of new stars that might be continually forming. The more perfect instruments of our time have shown us that the Milky Way is actually composed of stars, stretching so far away into infinite space that their form is almost lost in a faint shimmer of glory.

The nearer stars of the Milky Way, seen through the latest telescopes, appear but as the gleaming grains of sand, or the gold dust of worlds. On the far confines of what is visible there is still a luminous haze, suggestive of glories of creation stretching farther on into the dim infinities of space which mortal man may never hope to explore. This dim haze of stars has been aptly described as being "like a candle shining through a horn." Now we know that this candle shining through the horn is really the shimmer of countless blazing suns. Thus the conviction grows that beyond all the splendors of creation seen by man, incomparably greater glories remain behind.

A splendid invention has been made of late years whereby we have a clearer view of those remote stars, especially those of the Milky Way. I refer to the union of the photograph with the telescope. I think this is one of the happiest inspirations ever given to man. By placing in the focus of the telescope a highly sensitive photographic plate, millions of stars are revealed that are too far away to be detected by the telescope alone. Each faint dot in the photograph is a star, it may be thousands of times larger than our own sun. Some time ago, Professor Holden, of the Lick Observatory, sent me some of those photographs of the Milky Way. Anything more suggestive of infinity I have never seen. Thus the science of photography attains its divine mission of discovering new worlds; and thus we are ever widening our view of the illimitable creation.

The estimated number of stars has thus risen from the eighty millions of some years ago to five hundred millions. To appreciate this estimate in some degree let us make a supposition such as we made before, when we took a lower estimate. Suppose, then, that all these stars revealed by the telescope and photograph were brought so near that they could be seen by the naked eye. Suppose each one of them were to appear as large as Venus, though each of them is probably millions of times larger, Now we said that we can see eight thousand stars with the naked eye. But if we could see by the naked eye these

FIVE HUNDRED MILLIONS OF STARS

seen by the telescope, then for each one we see now we would see sixty thousand.

Try to realize what sixty thousand means. Then place that number of stars in the sky for each star you see now, and make each star as large as Venus. Can you imagine the effect? You certainly would not have room in the whole dome of the sky, round and round the world, for all these stars. The entire vault of heaven would be a solid dome of gold. You would have to pack the stars close together in many layers, to find room for them in the sky. You would find that you could take off a solid layer of stars, and still have a golden dome behind. Then you might take off another solid layer of stars, and still you would have a golden dome behind. Then you might take off another solid layer of stars, and still you would have a golden dome behind. And thus you might take off five hundred solid layers of stars, and after all you would have a golden dome behind! Oh, the immensity and glory of the starry hosts!

I may add here, that in this estimate, we have taken no account of the planets that may be revolving round those stars. It may be, that each star of those uncounted millions is the centre of a planetary system, like our own sun. Packed so closely together as the stars seem to be, there is plenty of room, probably, for each one of them to have a system of planets as wide and extensive as our own.

Of course no hint of this is given by the telescope. At such distances it is only the mighty central bodies that can be discerned, and even these appear but as motes in the sun. If planets there be, they will never be seen by man on this side of time. If you can, you may make room in your imagination for these supposed planetary worlds, and thus the immensity of creation will be increased. In the case of most, however, such an effort will bewilder more than it will enlighten; so we may let the planets go.

The view we have thus given of those uncounted suns is really overpowering. If it were not for the thought that man himself is really greater than them all, we might be utterly overcome. For the human soul is greater than all the stars. It is greater because it can think, can love, can adore.

There are some other interesting features of the stars that come more easily within our grasp. Let us take a glance at the stars that are called binary, or double stars.

Sometimes a star that appears single is really double; that is, it is composed of two stars. These, lying closely in the same direction, seem fused into one. A closer observation shows that there are two, with possibly millions of miles between them. In such a case, there is probably no special or intimate relation between the two.

In other cases there is a very special relation between the two bodies that compose the double star. A notable instance of this is Sirius, the brightest star in the sky. For a long time it was not suspected that Sirius had a companion star. This companion star

WAS FOUND BY ACCIDENT,

so late as 1862, in testing the power of a telescope. A little further observation showed that these two stars revolve round each other.

We have, therefore, in the case of Sirius, a system quite different from our own. Here we have one central sun; there, we see, there are two. But there s plenty of room between those two stars for each of hem to have a retinue of planets. If these exist, they are, of course, too distant to be seen. In those planetary worlds, if such there be, there may be two suns shining in the one firmament. Thus we get a hint of different orders of worlds elsewhere.

So early as the year 1781 eighty of these binary or double stars had been discovered. But since then the number has rapidly increased. A catalogue of them published some time ago gives the number as 596. What relations these double stars may sustain to each other is impossible in most cases to determine; but since the case of Sirius is so clear and so peculiar, we may well believe there may be similar or more remarkable combinations elsewhere. It would not be surprising, indeed, if there are systems where not merely two, but several suns, have combined and harmonious motions around each other. In the favored planets of such systems, therefore, there may be several suns in the same sky. We find that the farther our outlook into this marvellous creation, the more variety we find.

Still more remarkable than the binary, are the variable stars. These stars, from being very dim, increase in brilliancy; then, after a time, gradually wane to their former dimness, or disappear altogether. But the strangest thing is, that some of them go through stated periods of this kind. And some of them do this so regularly that their periods can be calculated.

These variable stars have been a long-standing puzzle to astronomers. There is no known cause for such curious behaviour. We have nothing analogous to it in this part of the universe, where it might be investigated and understood. If in all cases these stars

INCREASED IN BRIGHTNESS,

then gradually declined, and ultimately disappeared, we would no doubt be ready with our explanation of the phenomenon. We would probably say that such stars had burned themselves out. Each one of them would give us, as Professor Watts said, "the august spectacle of a world on fire."

In certain cases this explanation might be the true one. But it would not be true in the case of those stars that brighten and wane, and brighten and wane again ; and especially when they do this with periodic regularity. How such marvellous effects are produced, and what may be the consequent order of things in those distant starry realms, is far beyond our ken. But was I not right in saying a moment ago, that the farther we go afield into the realms of the stars, the more variety we find?

This subject of variable stars aroused great interest some time ago, on account of that star in the constellation Perseus, that suddenly glowed into brightneas, and then gradually waned to its former dimness. The transition in this case was great, ranging from the tenth to the second magnitude; but there has been no indication since that this star is going to repeat the process. This is not, therefore, believed to be a periodic star. And yet who can tell? It may possibly be periodic ; but with so long a period that there is no record of it doing a similar thing before.

I may mention a few of these extraordinary occurrences, and pass on, leaving the mystery where I find it, and where it will probably remain.

In the year 389 a certain star increased to the brightness of Venus, and disappeared. In 1604 a star appeared; brightened; waned; finally went out. In 1876 Dr. Schmidt discovered a star of the third magnitude, which in one year decreased to the seventh, later to the tenth, and almost disappeared. In 1866 Mr. Birmingham saw a star suddenly flashing out to the second magnitude. So it remained for several nights, and then faded until it was barely seen. Kepler discovered one that vanished in a few months. A white star declined from the fifth to the eleventh magnitude in 404 days, and then began to regain its lustre. In 1572 a star suddenly appeared, shone steadily for eighteen months, then disappeared.

These may be called casual variable stars. The most notable periodic one is Algol, which changes from the fourth to the second magnitude in three hours, less some minutes and seconds; then, changes back again exactly in the same time; and

THIS PERPETUAL MOVEMENT

is sustained with undeviating regularity through years and years. As we said, we can but leave the mystery where we find it. How little, after all, we know of this marvellous creation.

One thought more, and we shall leave this realm of beauty and mystery. We have tried to get some idea of the distances of the stars, of their clusters, of their bulk and brilliancy, of their number, and of the binary and variable stars. We would now glance at some of the different colors of the stars.

Yes, there is variety of color, as well as of size, brilliancy, position, movement, and what else. No doubt, white is the prevailing color ; but we discern stars of almost every tint ; and if we can do so from this poor vantage ground of earth, what concealed splendors may lie beyond our ken ? However, we shall confine ourselves to a few facts.

We have a hint of this variety of color in our own solar system. We have the silver planet Venus, and the red planet Mars. But these colors are not at all so pronounced on the planets as they are on the stars. This might be expected, for the planets are dull earth, while the stars are incandescent fire. So we have red and green stars, purple and gold stars, white and blue stars, violet and orange stars. Centauri, the nearest star, is red ; there are others of almost every hue.

It is notable that most colored stars so far discovered, belong to the class of binaries to which we referred a little while ago. I wished first to fix your attention on their peculiar movements as double stars. Now I wish you to see their remarkable colors, and the union of different colors in the same system.

There is also this further astounding fact to be noted : that, in many cases, stars pass in time from one color into another. Why this is so is, of course, a mystery. However, let us note certain verified facts.

Of double stars, Struve makes a catalogue of 596. Of these, 476 pairs are of the same color, and 120 pairs of different colors. Thus you see how the colored stars predominate in the binaries. Without giving the names of the double stars, I may note some combinations of the colors in different pairs. We have a combination of yellow and purple, of pale green and blue, of sea-green and orange, of blue and orange, of sea-green and pale orange, of white and light purple, of emerald green and orange, of yellow and sapphire blue, of greenish blue and bright blue.

This is sufficiently astonishing; but the astonishment increases when we consider how these colors change in indefinite periods. Sirius, now a white star, is described by Ptlomey as being red in his time. Two double stars described by the elder Herschel as white are now—one pair a golden yellow, and the other pair a yellow and reddish green. Dr. Hand, in 1850, described a star which in two years had changed from a red to a blue. The constellation Orion has a double star—a white and a blue. Orion has also

TWO BINARY SYSTEMS,

the one pair of stars being a white and a purple, the other pair a yellow and a blue. A variable star, discovered by Tycho Brahe, in four months passed through a variety of colors: first white, then yellow, then red.

I need not pursue these glorious mysteries further. I would only make this one reflection: that if mortal man, on this dim spot of earth, can catch even a glimpse of such heavenly splendors, what amazing glories may not the future life unfold?

CHAPTER XVII.

PLAN OF THE UNIVERSE.

Unity with diversity — Our limited outlook — Suggestions of variety—Different organisms—Adjustment to environment —Veracity of Scripture—The ideal human form—A grand theory exploded—Dr. Russell Wallace's fastastic dream— Eternal origin of all things—A place where the heart can rest.

IF I venture to speak of the plan of the universe, I do so, not with any idea of sketching such a plan, but rather to show that we have almost no conception of the plan as a whole. We see fragments of the plan ; there can be no doubt of that ; but the whole plan is too vast and too varied for mortals.

That there is a fundamental unity in the whole creation we cannot but believe. If all the varied order and adaptation which we see proceed from one Mind and one Hand, it must have a certain coherence and unity. And by going but a short way into the study of creation,

WE MAY DELUDE OURSELVES

with the idea that we know the plan.

If, for instance, we make a study of the solar system, and then learn that the myriads of fixed stars are all suns like our own, and go no farther, we are liable to imagine that we have found the plan of the universe. With such a limited outlook, we naturally suppose that the solar system is substantially repeated everywhere. We think simply of every star being the centre of a retinue of planets very like our own. We get the conception that the universe consists of small globes revolving around larger ones, and these in turn revolving around others still larger. I say, I think this is the conception we are likely to obtain from such a limited view of the universe as I have indicated.

Now such a conception may be so limited as to be altogether misleading. I have no doubt it is partly true, but I think it is a very small part of the whole truth. A wider survey of creation opens to us surprises as to variety of conditions in other systems and other worlds; and it is probable that the utmost variety of which we have even a hint may be as nothing to the greater variety of other systems and other worlds unseen.

I wish, then, to recall some circumstances suggestive of such variety. To be sure, these suggestions come to us from realms of beauty and mystery which may never be explored on this side of time. Yet even such suggestions may save us from short-sighted limitation and mistake; and, further, they may give direction to imaginations which cannot be entirely restrained.

First, I would say that the immense size and brilliancy of some of the suns are suggestive of other conditions than those that prevail here. This sun of ours is immense in size, and intense in heat; yet, what is our sun compared, say, with Arcturus? There we have a sun two hundred times brighter than ours. If there are planets circling round that sun, and if they are in keeping with his immensity and glory, splendors may be witnessed there but dimly suggested in our own smaller and meaner system.

Again; the varying magnificence of our planetary worlds may be reproduced on a much vaster scale in other systems. Compare our small earth, with its one small moon, with the splendor of Saturn, where eight large moons, and a series of luminous belts, irradiate that sky. If we have such variety here, in one small system, the varied and glorious effects that may prevail in other systems the imagination fails to conceive.

What seems to us the erratic movements of the comets, may be order and harmony elsewhere. The usual conception is, that the heavenly bodies all move in circles; but the comets suggest wider spaces and other motions—it may be in narrow ellipses, or curves, or straight lines. The universe is large enough for the widest conceivable evolutions.

Then there may be restless and agitated conditions elsewhere, such as we have not here. There is a

SOLEMN SILENCE AND REPOSE

in the movements of our planetary worlds. But the mighty system of Orion seems to be in a state of agitation, like the surface of a sea in storm. Who can say what conditions there are to be found in that quarter of creation?

The binary stars indicate that two suns may shine in one firmament at the same time. And it is not unlikely that groups of suns in other systems may have combined and harmonious movements. Thus, some favored worlds may have several colored suns.

We have seen, too, that many of the binary suns are colored, and the two composing a double sun, are often of different colors. Thus, it is fair to suppose that there may be worlds of unspeakable, changing splendors, where several suns of various changing colors irradiate the same sky. Compared with such glorious spheres how dull and dim is this earth home of ours.

The Pleiades is a group of about eighty stars. What complex yet harmonious movements may be executed within that constellation? There seem to be possibilities there of producing effects as different as you can imagine from those that prevail here.

And then, how curiously those worlds must be affected, if there are such worlds, that are controlled by the star Algol? This is the sun that waxes and wanes every three hours. How different those conditions must be from our own. And since we have really seen that curious phenomenon, how many other phenomena, much more curious, may be beyond our observation?

Most remarkable of all, perhaps, and most beautiful, are the changing colors of certain stars. The magnificent changing scenery that may be witnessed there is beyond imagination.

Then, the variety of bodily organization and modes of life even here suggest far greater variety elsewhere. When we see that in this world certain animals can live in the sea, others on the land, and others in the air; and when we see how all classes are adapted to their environment, we may try to imagine what variety may prevail in so many other different worlds.

Especially in organization there may be the most striking differences. I hinted before that beings may be so organized as to live in fire. You may say this is impossible; but if you had been told, before you saw it, that certain animals could live in water, you would have deemed that equally impossible. Thus we see that worlds of the highest temperature may be inhabited. The dwellers on the hottest spheres may be as comfortable as were the three faithful Hebrews in the burning, fiery furnace.

And as there may be various organisms, so there may be various modes of sustenance. We may not assume that there is vegetation in all worlds because we find it here. Such a thing may possibly be quite unknown in certain other regions. How would the inhabitants of such worlds be sustained? We cannot say; but there may be

OTHER MEANS JUST AS NATURAL

as vegetation. The Israelites in the wilderness were fed by manna that dropped every night from the heavens. If you say that was a miracle, I say, that in the truest sense, it was no more a miracle than vegetation. At any rate, it gives us a hint that in some other worlds there may be ways of sustaining life just as good as our way of eating the produce of the field.

And here I would interpose one word in behalf of the veracity of the sacred records. It is becoming the fashion now to explain away the miraculous. And this is held to be a sign of learning, and of profound, far-reaching views. I think it is much more a sign of limitation and ignorance. If we knew a little more of the facts of creation, I believe that we should find that many things in Scripture, now explained away, would be seen to be perfectly in harmony with nature's higher laws. I have instanced the case of the Hebrews in the fire, and of the manna in the wilderness; and there are others.

Speaking of different organisms, I have the idea that the human form is the typical, ideal form in all worlds. I have more reasons for this view than I can state here. This human form I take to be the human form divine. It may have various modifications in various worlds, and yet not lose its essential type. Thus we may be really akin with the inhabitants of all worlds. We may be of different races, yet universally human.

As further evidence of the variety that prevails in nature, I would instance the law of attraction. I suppose that above all things the law of attraction is held to be universal. But who knows that it is universal? It may be a law of very wide sweep, without being universal. It may hold the solar system together, it may even hold many systems in place, and yet not be universal. In other realms of creation there may be other governing forces, or even other forms of attraction.

Why is the needle attracted to the pole? We do not know. But may not this singular thing suggest other laws of attraction, not universal, but local? Might not the north polar star, or some star far beyond it, be a magnet? And might not the surrounding planets be so constituted as to be controlled by that magnet? And in the wide immensities of creation may there not be special attractions, or other forces, of which at this distance we have no knowledge whatever?

Now, I think you will see that these are not mere speculations, but reasonable possibilities, suggested to show that there may be more variety in the universe than our philosophy has dreamed of.

Some years ago there was launched a very unifying theory of creation that may be glanced at here. This was the theory of a grand central sun around which all the suns revolved. Such a sun was supposed to be of incalculable size, and proportionately distant, to be the centre of creation. There were two circumstances that gave a slender support to this theory. First there was a very limited analogy. There was the fact that in this one system of ours moons revolve round planets, and planets revolve round the sun. By a hasty induction it was assumed that all the suns in their turn revolve around a central sphere. This is the fault of too many scientific men—they sometimes generalize too quickly. In astronomy it may perhaps be pleaded that this is inevitable, because this is a realm of so much mystery. But, on the other hand, this is about the most tremendous assumption that man could make, involving, as it does, every globe in creation; and such an assumption ought not to be made hastily.

The other circumstance that favored the theory was the opinion that our sun himself was moving, and carrying all his planets along with him, towards the constellation Hercules. From observations made at wide intervals it was believed the stars in Hercules had drawn a little apart. This was the indication that we were moving in that direction. So this mere belief that the sun was moving, was pressed into service to support the theory of a grand central sun. Yet it is calculated that Hercules is distant from us twenty millions of millions of miles, and that the sun, though moving with immense speed, would not arrive there for a million of years. You will see, therefore, how slender was this support of the theory of a central sun.

But there was another circumstance quite sufficient to shelve this grand theory. So eager were astronomers to complete their theory, that different authorities claimed different stars as the supreme grand centre. It seems strange that any star would be so claimed; for the theory would seem to require one so far away as to be utterly unseen and unknown. But no;

THE THEORY WAS SO FASCINATING that astronomers must needs complete it by indicating the very centre of all the suns. But here they disagreed. Kant took Sirius; Lamont selected Orion; Mardler preferred Pleiades. No theory, of course, could stand such contradictions.

Now, it may be that after all, this sublime guess is true. It is, however, nothing but a guess. I have referred to it to show how ready men are to form conclusions without sufficient data. And I regard this as specially unfortunate in regard to the glorious facts of astronomy. Of all sciences, astronomy ought to be a science of demonstration.

I am led here to glance at a remarkable theory put forward some time ago in *The Fortnightly Review*. The author of the theory in question is Dr. Alfred Russel Wallace, a man of acknowledged scientific ability. The reference made a moment ago to the superiority of man to all physical creation, leads me to notice the theory of Dr. Wallace, for he gives man the most unique and astounding superiority we can conceive. His theory is, that the solar system is the centre of the universe, that the earth is the only inhabited globe, and that the entire creation was ordered and designed for man's sole benefit and accommodation.

Such is the startling theory. Startling indeed it is in its primitive simplicity, but more startling because of its utter unreasonableness and unscientific character. I doubt if we can find anywhere a more striking example of the fact that great men are not always wise.

I can but sketch here in a few words Dr. Wallace's defence of his theory. He contends that astronomcal observations show a probable end of the universe of stars in a certain direction. He says that the stars are more thinly scattered the farther we proceed outwards, and that still farther out there are none. I am not aware that he brings his colossal measurements to bear in every direction, which seemingly he would need to do, to establish his theory. No; but by a short and simple cut he assumes that our sun is the centre of all, and the earth the only place of habitation. The learned author will forgive me if this sketch of his argument is too brief; it is certainly not meant to be unfair.

In answer to this assumption, surely it is only necessary to refer to the facts we have advanced in reference to the immensity and glory of creation. There is really no end to it that man can see. Whether you think of the immensity of space through which even the visible universe extends, or the uncounted hosts of created suns, or the superior size and splendor of many of these suns, you will marvel that a sane man could launch such a theory as the one we are considering.

Our own solar system, to go no farther, ought to settle the question. Of the eight planets circling around the sun, the earth is one of the smallest, and the meanest, without any suggestion whatever of being in any way more important than the others, And this dim earth is supposed to be the chief spot in the splendors of creation.

But think of the inconceivable spaces the Doctor undertakes to measure. Ponder this fact. Light, that would flash round our globe seven times in one second, would need ten thousand years to cross the Milky Way. Such is the sober calculation of responsible astronomers. Ponder the fact. It is utterly bewildering. Yet this is the abyssmal space that Dr. Wallace undertakes to measure to sustain his theory. And if he could measure it, he would need to measure it in every direction, so as to place us in the centre. Moreover, beyond the utmost bound of vision there may stretch out other universes of stars vaster than those we see. But Dr. Wallace assumes that he sees almost the bounds of the whole creation. So far from seeing this, the probability is, we cannot even conceive it.

"Can man conceive beyond what God can do?" Most surely not. But our daring author would need not only to conceive, but to measure, the entire abyssmal universe before he can discover where to place us in the centre.

Then think of the amazing number of suns which Dr. Wallace relegates to a position inferior to ours. There is no counting of the suns in the Milky Way. Let any person look at a telescopic photograph of the Milky Way, lately taken at the Lick Observatory. Anything more suggestive of infinity I have never seen. We stand in awe as we contemplate these uncountable starry hosts. But every one of these Dr.

Wallace coolly assumes to have no dignity like that of our sun. They are all simply blazing fires, of no account to any intelligent beings, while our sun has the dignity and glory of ministering to the one race of intelligent creatures in God's illimitable universe.

Add to this, the surpassing size and glory of many of those other suns of which Dr. Wallace's theory requires him to make of such small account. It is well known that many of those suns far surpass our own in bulk and brilliancy. As we go out into space, the first sun we meet with beyond our own, gives four times as much light. Vega gives forty times as much; Sirius, fifty times, and Arcturus two hundred times. But these splendors our author has to ignore in making out his theory.

Then there are suns of every color, casting, it may be, unimagined glories on surrounding planets. But our author forgets all this in his enthusiasm for his new theory.

Further than all this, there is a moral aspect of this fantastic theory which is not less fatal to it than the physical aspect. But into this I cannot go just now.

I can only express my regret at this aberration of a great mind. The most sane men seem to need a warning now and then not to be too quickly enamored of a beautiful theory. I confess I can find no bases for this new doctrine in scripture, or analogy, or common sense.

And yet, there is one way of rendering this theory of Dr. Wallace acceptable even to the most critical.

If the author of the article in *The Fortnightly Review* will add but one sentence to what he has written, there will not be much room for controversy. And the sentence which I would respectfully commend to to him is the following: "Then I awoke, and behold, it was a dream."

Where, then, is the plan of the universe? It has disappeared. It is utterly beyond us. We see a fragment of the plan in this solar system; but this system is a point only in the wide creation. We see but a little way; yet the little we do see gives us

HINTS OF ENDLESS VARIETY

in other far off realms. For us to speculate about the plan of the universe as a whole, would be like insects dwelling on a rose leaf speculating about the nature and quality of all the flowers.

Yet, while we are almost lost in the greatness and glory of creation, we have one immense relief. We cannot but know that all the marvels of the universe are the product of supreme intelligence and almighty power. In that conviction there is rest. The mind refuses to believe that these marvels were evolved by chance or blind law. Behind all chance and all law there is a living God. Neither the mind nor the heart can rest in any secondary cause; the only resting place is the mind and heart of the Eternal.

And when once we recognize God as the divine, personal Creator, we begin to see why there are no limits to the unfolding glories of the universe. They are of God; that explains everything. He has all power to execute his will. He has all eternity in which to complete his designs. He has all wisdom to direct him in the choice of means and effects. He has all space for the outgoing of his creative energy. He has all beneficence to do the most and the best for his creatures. And he has in himself supernal beauty wherewith to beautify all the works of his hands. Then under such conditions—

> "Can man conceive beyond what God can do?
> He summons into being with like ease
> A whole creation and a single grain.
> Speaks he the word? A thousand worlds are born!
> A thousand worlds! There's room for millions more!"

CHAPTER XVIII.

TELESCOPES.

The first telescope—Galileo—Newton—Herschel—Rosse's telescope—Later developments—Immense complicated machines—Lick observatory and instruments—Yerkes observatory and instruments — An ever fascinating field—No limit to glories of creation.

IT is doubtful to whom the award is due for conceiving and constructing the first telescope. However rude or small the first one may have been, it marked a new era in discovery. It opened the heavens, and showed us worlds before unseen. Like all great inventions, it was very imperfect at first; but the main principle being discovered, improvements were effected from time to time, so that from being at first a small toy, it has now developed into an immense, complicated machine.

The first telescope was probably made about the end of the sixteenth century. By whomsoever it was made, it is pretty clear that Galileo was the first to apply it to any serious use. In this it resembles the art of photography. For many years photography was only a recreation. Now it is applied to many important uses; but its highest mission is in uniting with the telescope in the discovery of new worlds.

If we could place the first small, rude telescope side by side with our most modern ones, how striking would be the contrast. And almost as great, perhaps, is the contrast in the achievements of the earlier and later instruments. Yet in the very earliest stages of the telescope wonderful discoveries were made. With his own hands Newton constructed many telescopes, and with these made great discoveries. The elder Herschel did the same; and the younger one worthily succeeded him.

The immense telescope of Lord Rosse made the most signal advance. This telescope far exceeded in size and power all previous ones. At the same time it gave the signal for still farther advance; and now it has been far surpassed.

The director of the Lick Observatory has very kindly sent me photographs of that building, and also of the immense Lick telescope. The director of the Yerkes Observatory has also done me a like favor. I am under a similar obligation to the director of the Observatory of Toronto. These great institutions are equipped with the latest and best instruments, and manned by the foremost astronomers of our time.

The director of the Observatory at Toronto has sent me the following description of the instruments in use in that institution.

"The astronomical instruments of the Toronto Observatory consist of a six inch equatorial telescope by T. Cook & Son of York, England, driven by clock work and mounted on a stone pier 40 feet in height, inside the tower of the Observatory. This tower is surmounted by a dome movable on wheels, running in a circular tramway so that the opening in the dome can be placed at any desired azimuth.

The telescope is supplied with eye pieces ranging from powers of 80 to 500. Also a solar reflecting prism, for viewing the sun, and a right angled eye prism for convenience of observing. In the transit room is mounted a fine three inch transit by Troughton & Simms, London, of which I send you a photograph. The transit reticule consists of a glass diaphram with two horizontal lines. The vertical lines are 25 in number, and are ruled so as to cover half the field of view, every third one being ruled all the way across, thus giving two systems of wires, one of 25 wires and one of 9 wires.

The transits of the stars are registered upon a chronograph in the clock room, in which are also two large clocks beating seconds, one keeping Sidereal time and the other Mean time of the 75th Meridian, mounted on separate stone piers and having electrical contrivances for disseminating the time. Several chronometers are also in the room."

In the science of astronomy, perhaps above all others, there is unlimited scope for new discovery. And the unfolding glories of creation have an everlasting charm. What new realms of wonder may yet be explored, who can say? Larger telescopes may be constructed, or there may be new inventions in optics. In either case, our vision may yet be vastly extended. We may well believe, however, that with our ever-widening vision, there will be an ever-widening universe. And we may be sure that our ambition for discovery will keep pace with our possibilities. Thus, new marvels of creation will ever lure us on toward the realm of the infinite.

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